Revised Final Report

Use Attainability Analysis for Old Alamo Creek

Submitted to:

Environmental Protection Agency

Region 9

Prepared by:

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1. Introduction

Section 303(c) of the Clean Water Act (CWA) requires each State to develop water quality standards that protect the chemical, physical, and biological integrity of the State's waterbodies.

Water quality standards under the Clean Water Act consist of three elements: Use Classification, Water Quality Criteria, and Antidegradation Policy (CWA § 303(c)(2); 40 C.F.R §§ 130.3, 131.6, 131.10, 131.11). Use Classification, termed "beneficial uses" under California law, are "uses specified in water quality standards for each water body or segment whether or not they are being attained." (40 C.F.R § 131.3(f)). Beneficial uses must be consistent with the goal of CWA section101(a)(2), which is to provide for "the protection and propagation of fish, shellfish, and wildlife and ... recreation in and on the water" (the so-called "fishable/ swimmable"uses), unless the state demonstrates that those uses are not attainable. Beneficial uses must also consider, among others, the use and value of water for public water supplies, agriculture and industry, and the water quality standards of downstream waters (40 C.F.R. § 131.10).

Beneficial uses for surface waters in the Central Valley Region of California are designated in *The Water Quality Control Plan (Basin Plan) for the California Regional Water Quality Control Board Central Valley Region, Fourth Edition, 1998 Sacramento River Basin and the San Joaquin River Basin*. The Basin Plan lists the beneficial uses for approximately 100 water bodies under their jurisdiction. When a specific waterbody is not included on this list, the tributary statement is used. It asserts:

> *The beneficial uses of any specifically identified water body generally apply to its tributary streams. In some cases a beneficial use may not be applicable to the entire body of water. In these cases the Regional Water Board's judgement will be applied. It should be noted that it is impractical to list every surface water body in the Region. For unidentified water bodies, the beneficial uses will be evaluated on a case-by-case basis* (Regional Water Board CVR 025, p. [II-2.00].)

Old Alamo Creek is located near the City of Vacaville in the Central Valley Region of California. Old Alamo Creek is not listed in the Basin plan and is a tributary eventually to the Sacramento/San Joaquin Delta. Therefore, according to the tributary statement, the beneficial uses for the Delta are applicable to Old Alamo Creek. These beneficial uses include public and domestic water supply (MUN), irrigation and stock watering (AGR), industry process (PRO) and service supply (IND), contact (REC-1) and non-contact (REC-2) water recreation, freshwater habitat for warm (WARM) water species, freshwater habitat for cold (COLD) water species, migration of warm and cold aquatic organisms (MIGR), spawning, reproduction, and/or early development of fish species (SPWN), wildlife habitat (WILD), and navigation (NAV). Also, Resolution No. 88-63 the State Water Resource Control Board's "Sources of Drinking Water Policy" established state policy that all surface and ground waters of the state are considered sources of drinking water with certain exceptions. The Central Valley Regional Water

Quality Control Board (RWQCB5) implemented Resolution No. 88-63 by designating unlisted waters as municipal and domestic water supply (MUN).

Old Alamo Creek has never been evaluated to determine if the COLD, MIGR, SPWN, or MUN beneficial uses are, in fact, appropriate to this waterbody. Definitions of these beneficial uses are summarized in Table 1-1. Preliminary assessments indicated that several of these beneficial uses may not be appropriate.

Beneficial uses attained on or after November 28, 1975 are “existing uses” and indicate that there is evidence that the use is occurring or that water quality is sufficient to allow the use to occur. A beneficial use that is determined to be “existing” may not be removed. To remove a use that is not intended to satisfy the minimum of Clean Water Act section 101(a)(2) (i.e. it is not a “fishable/swimmable” use), it must be demonstrated that the use is not attainable through one of the factors listed in 40 CFR 131.10(g). Such a demonstration is referred to as a showing. To remove section 101(a)(2) uses a use attainability analysis (UAA), supported by at least one of the factors listed in 40 CFR 131.10(g), must be conducted. (U.S. EPA Water Quality Standards Handbook, pp. [2-6]-[2-8].)

The Central Valley Regional Water Quality Control Board determined that site-specific Basin Plan amendments are necessary to change uses assigned by the tributary statement. Therefore, the purpose of this UAA is to provide an assessment of the beneficial uses listed in Table 1-1 in Old Alamo Creek (see Table 1-1). Where applicable, the Regional Board will use the results of this UAA and the public process to amend the Basin Plan to establish site-specific beneficial uses for this waterbody.

Table 1-1. Summary of beneficial uses examined in the Use Attainability Analysis and their definitions as stated in the current Basin Plan for the Sacramento and San Joaquin River Basins (RWQCB, 1998).

Beneficial Use	Definition
Municipal and Domestic Supply (MUN)	Uses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply.
Cold Freshwater Habitat (COLD)	Uses of water that support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.[1]
Migration of Aquatic Organisms (MIGR)	Uses of water that support habitats necessary for migration or other temporary activities by aquatic organisms, such as anadromous fish.[2]
Spawning, Reproduction, and/or Early Development (SPWN)	Uses of water that support high quality aquatic habitats suitable for reproduction and early development of fish.[2]

[1] COLD beneficial use applies to resident species only.
[2] MIGR and SPWN beneficial uses apply to anadromous and catadromous species.

2. Characterize the Segment and Watershed

2.1 Physical Environment: Geology, Geomorphology, Hydrology, Channel processes for the Central Valley, California

The Central Valley is a flat alluvial plain located in the California Dry Steppe Province ecoregion (Bailey, 1995) covering about 39, 956 square miles between the Sierra Nevada and Coast Ranges (Figure 2-1)(California Dept. of Finance, 2001). This Central Valley consists almost entirely of two major river basins, the Sacramento River and the San Joaquin River. The Sacramento River drains both the east and westside of the Northern Central Valley, while the San Joaquin River drains the southern Central Valley. The westside streams generally have streamflows limited in volume and seasonal availability due to the lesser amount of snowfall west of the valley. Some westside streams, such as Cache and Putah creeks, do not connect with the Sacramento River at all during dry years and hydrologic connections are only occasional depending on the amount of precipitation (Yoshiyama, et al., 1998). This area has broad, nearly level valleys bordered by sloping alluvial fans, slightly dissected terraces, and the lower foothills of the surrounding uplands. Climate is characterized by hot, dry summers and cool, moist winters with rainfall occurring mostly during the period of November through April (Witham, et al., 1998).

California's Great Central Valley once supported a diverse array of perennial bunchgrass ecosystems including prairies, oak-grass savannas, desert grasslands, as well as a mosaic of riparian woodlands, freshwater marshes, and vernal pools. In its original state, it comprised one of the most diverse, productive, and distinctive grasslands in temperate North America (Barbour et al, 1993; Schoenherr, 1992). The predominant landscape feature of the Central Valley today is a wide variety of agricultural croplands. The Valley is intensively farmed and produces over 250 crops shipped to worldwide markets. The region is the mainstay of the multi billion-dollar agricultural economy in California. The productivity of the Valley is made possible through irrigation water supplied by a network of delivery canals and reservoirs. A major component of this water delivery system is the Central Valley Project (CVP) managed by the Bureau of Reclamation. The CVP and other water delivery systems managed by the state have had a major impact on the development of the Central Valley (Sweeney, 1991).

In recent years the Valley has experienced tremendous urban growth, which has created additional pressures on resources. The flow in many small streams in the Central Valley is dependent on, or greatly influenced by, discharges of wastewater from municipal wastewater facilities and/or agricultural drainage. These streams are referred to as Effluent Dominated Waters, or EDWs. Information collected by a variety of sources in recent years suggests that certain designated uses may need to be re-evaluated for some EDWs in the Central Valley. For example, COLD or MUN use may not be attainable given the physical constraints of these systems. Some of these designated uses can have significant effects on certain water quality objectives, such as dissolved oxygen, ammonia, and priority pollutants. Due to the limited dilution capacity in EDWs, National Pollutant Discharge Elimination System (NPDES) permit limits are usually set equivalent to receiving water limits, which are based on water quality objectives and beneficial uses adopted in the Basin Plan. Therefore, it is important that such uses be evaluated to ensure that they are attainable and therefore appropriate.

Despite its urban and agricultural development, the Central Valley serves as a major migration corridor and wintering ground for millions of migratory birds in the Pacific Flyway (Stein et al., 2000). The Valley is also a migratory corridor for many anadramous fish species such as Chinook salmon, steelhead trout, shad, and sturgeon. Several fish species such as Sacramento blackfish and Tule perch, are endemic to the valley, however, in many habitats, native taxa comprise a small percentage of the fauna and flora (Moyle and Nichols, 1974; Brown and Moyle, 1993; Brown, 2000; Domagalski et al., 2000). Agricultural development, urban expansion, alteration of hydrologic regimes and channelization, grazing by domestic livestock, fires, and introduced plants and animals have all contributed to the alteration of native habitats (Brown and Moyle, 1993; Brown, 2000, Barbour et al., 1993).

2.1.1 Hydrology of Old Alamo Creek

The headwaters of Alamo Creek are located in the Mayacmas Mountains west of Vacaville in what is considered the Southern and Central California Chapararral and Oak Woodlands (SCCCOW). However, the majority of what was once Alamo Creek flows through the Central California Valley (CCV) ecoregion. The chief differences between the two ecoregions are that the SCCCOW is hilly to mountainous and agricultural operations are much less intense.

As illustrated on the map in Figure 2-2 Alamo Creek flows into Vacaville from the west. As part of Soil Conservation Service (now the Natural Resources Conservation Service) efforts to control flooding in the Ulatis Creek drainage area, the flow from Alamo Creek was diverted to a constructed channel built in 1965 (now known as New Alamo Creek) leaving what is now known as Old Alamo Creek disconnected from most (~60 %) of its watershed. Flows originating from higher elevations now travel down New Alamo Creek. Parts of what is now Old Alamo Creek were straightened to control flooding as well. However, much of Old Alamo Creek has not been significantly modified compared to other sections of the creek, nor has it been structurally modified to collect and convey wastewater or agricultural return water.

According to the Environmental Impact Report produced for the expansion of the Vacaville WWTP, the flow of Alamo Creek was diverted into New Alamo Creek in 1966. Diverting the flow left Old Alamo Creek dry for part of the year except for the section downstream of the Vacaville Easterly Waste Water Treatment Plant (EWWTP). Flow upstream of the discharge is often reported to be zero during dry periods of the year and highly variable during the rainy season, sometimes reaching zero flow (RWQCB, 2002). During the dry season, flows in Old Alamo Creek, upstream of the discharge, originate from urban and agricultural runoff and treated groundwater discharging under a General Order NPDES facility (Kinder Morgan Energy Partners L.L.P.). The current "headwaters" of Old Alamo Creek are located in the Eleanor Nelson Park (Figure 2-3). The photo presented in Figure 2-4 is taken just above the "headwaters" of Old Alamo and is the beginning of the diversion channel now known as New Alamo.

Approximately 3.2 miles downstream from the Vacaville EWWTP discharge, Old Alamo Creek enters New Alamo Creek through a set of four iron flapper gates (Figure 2-5). The stream channel for the combined flows of New Alamo and Old Alamo Creeks has also been channelized and is considered to be "New Alamo Creek". After another 3.3 miles, New Alamo enters Ulatis Creek, the confluence of which is within the legal boundary of the Sacramento-San Joaquin Delta. Ulatis Creek enters Cache Slough 12.2 miles downstream from the discharge point. Within Cache Slough is an emergency drinking water intake for the City of Vallejo that has not been used since 1992 (RWQCB, 2002).

Thus, what was once a single integrated stream has now been divided into four segments: 1) Alamo Creek - a relatively undisturbed channel in the upper watershed; 2) New Alamo Creek – a human-made channel conveying the flow from Alamo Creek; 3) Old Alamo Creek - a natural stream channel with flows formed from stormwater from adjacent neighborhoods, irrigation return flows, a groundwater mitigation well, backwash from municipal water supply wells, discharges from the Vacaville EWWTP, and irrigation return flows; and 4) the confluence of Old Alamo and New Alamo into a stream channel that has been channelized and has an intensively managed riparian corridor. This UAA addresses beneficial uses in Old Alamo Creek only, however, information concerning New Alamo and Upper Alamo Creek were used as well in this evaluation.

2.1.2 Description of Point and Nonpoint Sources

Vacaville's EWWTP is a secondary treatment system built in 1959 that discharges to Old Alamo Creek approximately 1000 feet from Vaca Station Road (Figure 2-2). As part of expansion and construction at the plant, the discharge point will be moved 892 feet downstream and is expected to be in service by the summer of 2003. The plant's current design allows for an average dry weather flow of 10 million gallons per day (mgd). The design for the expanded plant allows for an average dry weather flow increase to 15 mgd. The current design peak wet weather flow is 27 mgd and after expansion will be 55 mgd. Vacaville projects an additional plant expansion with a design average dry weather flow of 17.5 mgd by 2012 and a buildout expansion with a design average dry weather flow of 22 mgd by 2020. Current average flows are approximately 8.1 mgd (RWQCB, 2002).

In addition to the discharge from the EWWTP Old Alamo Creek carries stormwater runoff and effluent from the Kinder-Morgan groundwater remediation project. Kinder-Morgan's discharge is approximately 0.07 mgd. Neither of these sources provides a consistent source of dilution for the EWWTP discharge.

Growers within the Solano Irrigation District SID use fairly large quantities of water to grow a number of crops and for pasture (see next section), some of which is then returned to the Creek as runoff. Fry Ranch lies within the Old Alamo Creek watershed but is not served by SID. This operation diverts flows from Old Alamo Creek to grow pasture, wheat, sugar beets and corn. (Report of Licensee for Fry Ranch, 1993.)

The SID return water enters Old Alamo Creek approximately one mile downstream of the EWWTP discharge point. Irrigation deliveries and estimated runoff quantities between 1990 and 2000 are provided in Table 2-1. Estimated agricultural return water (runoff) to the Creek ranged between 1400 and 5100 acre-feet (456 – 1661 million gallons) with an average of 2527 acre-feet (823 million gallons). On an average daily basis these return flows range between 1.24 and 4.5 MGD. However, given that return flows are typically higher during the drier season when irrigation is needed (April – October), the estimated runoff from SID to the Creek may be as high as 8.3 MGD during some months, which is approximately 50% of the total dry weather flow in Old Alamo Creek. On average, the SID return flows may be 4 – 5 MGD in the drier months, or approximately one-third of the total flow during those times. Thus, SID return flows are a significant portion of the downstream flow in Old Alamo Creek.

Table 2-1. Water delivered to the Solano Irrigation District (SID) and estimated runoff to Old Alamo Creek by year between 1990 and 2000.   (Source: City of Vacaville, Easterly WWTP Receiving Waters Survey Report Supplement, p. 7.)

Year	Water delivered to SID area, acre-feet	Estimated runoff from Alamo SID Area, acre-feet
1990	13,360	2,700
1991	7,750	1,600
1992	14,190	2,800
1993	13,150	2,600
1994	11,830	2,400
1995	11,000	2,200
1996	17,980	3,600
1997	25,250	5,100
1998	8,860	1,800
1999	6,960	1,400
2000	8,200	1,600

2.1.3 Land Uses in Old Alamo Subwatershed

Solano County supports approximately 400,000 people (with approximately 90,000 living in the City of Vacaville), according to the 2000 Census (Table 2-2, source: http://census.mtc.ca.gov/counties/SolanoCounty.htm.

The drainage of Old Alamo Creek is dominated by agriculture (83%), with the remainder largely as residential area (15%) and urban (3%) (Figure 2-6). Agriculture is diversified with approximately 70 different commodities including fruits, nuts, vegetables, grains, seed, nursery stock and livestock. Solano County is in the top five California counties for the production of sheep and lambs, corn, and Sudan grass hay (www.co.solano.ca.us). Residential (4%) and urban (3%) build up are limited to the upper watershed around the southern end of the City of Vacaville (Figure 2-6).

The riparian vegetation in the upper part of the creek is composed primarily of hardwood trees, with grass and forbs intermixed (Figure 2-7). Large woody debris and root wads are primary habitat components throughout the stream channel above Sampling Station OA10. At and downstream of sampling station OA10, the stream channel has been channelized and the riparian corridor is intensively managed (Figure 2-8). These conditions persist to the confluence with New Alamo Creek and on to the confluence with Ulatis Creek.

2.1.4 Climate of the Region (Solano County)

Solano County area averages 63 cm (25 inches) of rainfall a year and experiences a Mediterranean climate in which most of the precipitation occurs in the winter months (November – March) (Figure 2-9). Air temperature ranges from an average low of 8° C in the winter to an average high of 32° C during the summer months (http://ggweather.com/climate/Vacaville.htm). Average maximum air temperature generally is above 12° C throughout the year.

Table 2-2. Summary of population census statistics for Solano County.

	Population	Percent of County
Solano County	394,452	NA
Fairfield	96,178	24.4
Suisun	26,118	6.6
Vacaville	88,625	22.5
Dixon	16,103	4.1
RioVista	4,571	1.2
Benicia	26,865	6.8
Vallejo	116,760	29.6

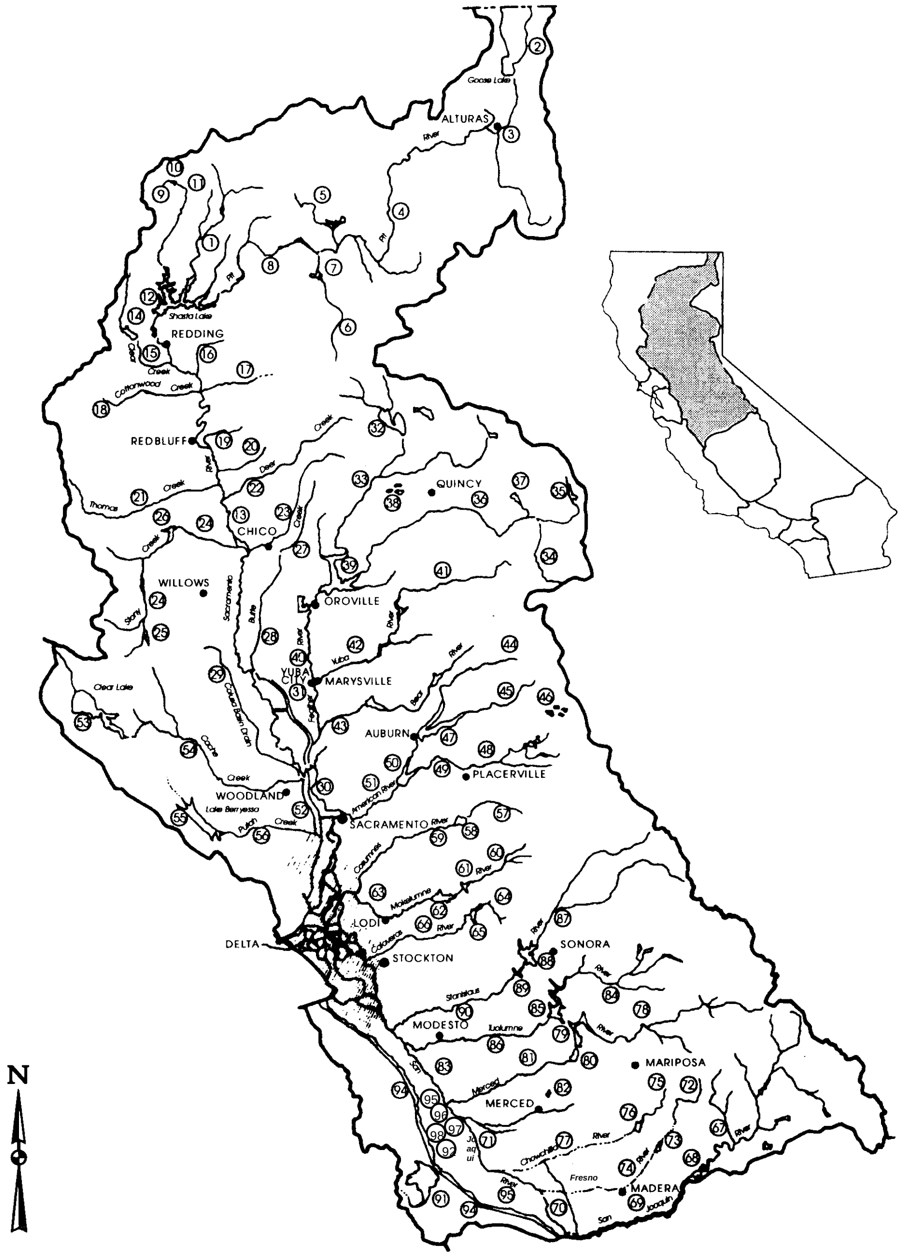


Figure 2-1. Basin plan map for the Sacramento River and San Joaquin River basins of the Central Valley.

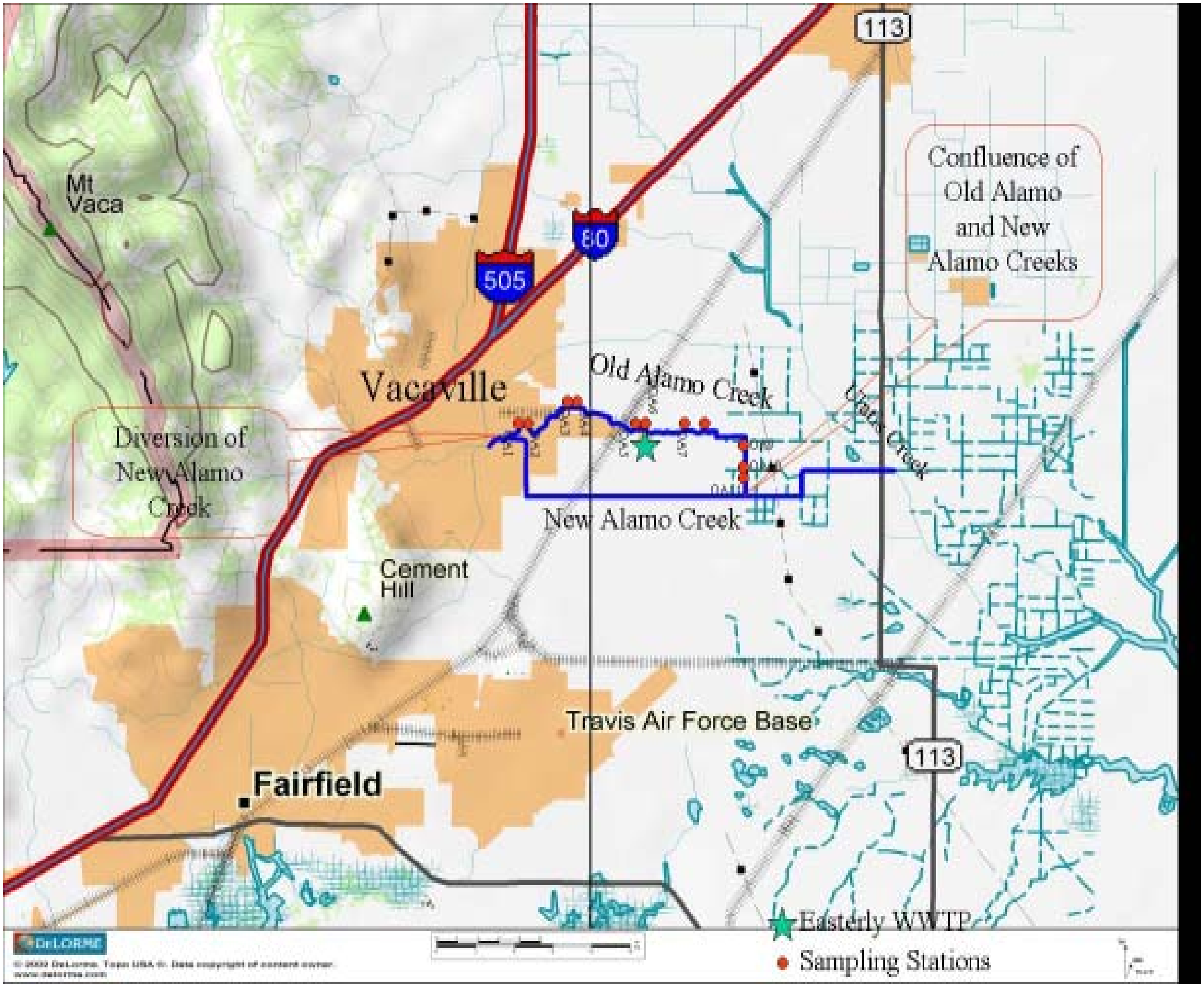


Figure 2-2. Regional map with sampling locations and key features.

Figure 2-3. Dry remains of the headwaters of Old Alamo Creek in the Vacaville City Park.

Figure 2-4. The diversion at New Alamo Creek from Alamo Creek just above the headwater of Old Alamo Creek.

Figure 2-5. Flapper gates at confluence of Old Alamo Creek and New Alamo Creek.

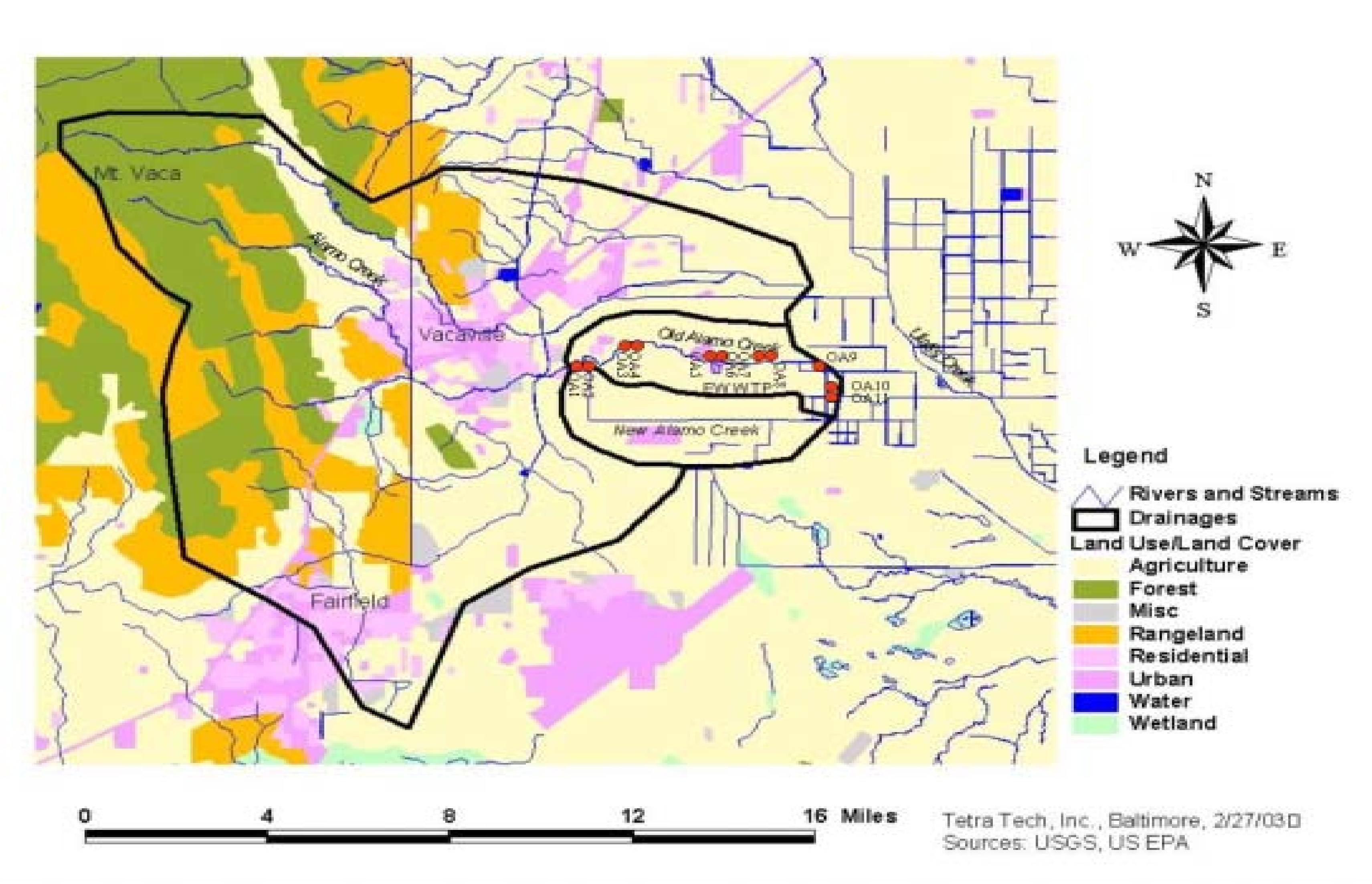


Figure 2-6. Land use and drainage for Old Alamo Creek, New Alamo Creek, and Alamo Creek.

Figure 2-7. Example of riparian vegetation in the upper part of Old Alamo Creek illustrating the relatively undisturbed channel there.

Figure 2-8. The lower reaches of Old Alamo Creek have been channelized and are managed (riparian canopy removed) to convey irrigation return waters.

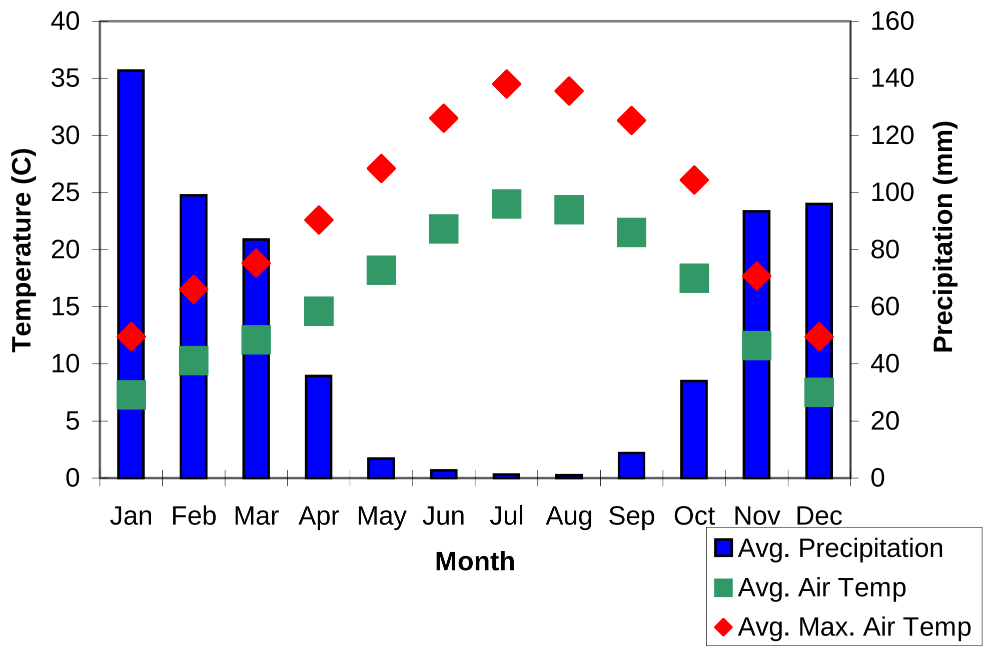


Figure 2-9. Maximum and average air temperature and average monthly precipitation for the Solano County area, including Vacaville and Old Alamo Creek.

3. Methodology

A use attainability analysis (UAA) is a structured scientific assessment of the physical, chemical, biological, and economic factors affecting the attainment of a designated use (USEPA, 1994). The purpose of a UAA is to provide information upon which to base the decision on whether a designated use is attainable or not. The regulations at 40 CFR 131.10(g) specify six factors that may provide a legal basis for changing or removing a designated use:

(1) Naturally occurring pollutant concentrations prevent the attainment of the use;

(2) Natural, ephemeral, intermittent, or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharges without violating State water conservation requirements to enable uses to be met;

(3) Human-caused conditions or sources of pollution prevent the attainment of the use and cannot be remedied or would cause more environmental damage to correct than to leave in place.

(4) Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use.

(5) Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unless these conditions may be compensated, unrelated to water quality preclude attainment of aquatic life protection uses.

(6) Controls more stringent than those required by Sections 301(b) and 306 of the Clean Water Act would result in substantial and widespread economic and social impact.

To remove a designated use that is not an existing use (or adopt sub-categories of a use which require less stringent criteria), it must be demonstrated that attaining the designated use is not feasible under any of the six conditions listed above. If a state wishes to remove any fishable/swimmable uses of CWA section 102(a)(2) or adopt sub-categories of those uses, it must perform a UAA (40 C.F.R. § 131.10(j)). Prior to removing a use or establishing sub-categories of a use, the state also must provide notice and an opportunity for a public hearing (40 C.F.R § 131.10(e)). Finally, if a state wishes to designate uses for the first time that are not fully protective of fishable/swimmable uses, a UAA is also needed.

The determination of whether or not a use is “existing” must include an evaluation of both the actual occurrence of the use activity (e.g., have coldwater fish been present or have people used the water as a source of drinking water?) and whether or not the level of water quality necessary to support the use has been achieved at any time since November 28, 1975 (i.e., a level of water quality that has been achieved within that time period cannot be deemed unattainable). If the level of water quality necessary to support a use has been achieved within that time period, the use is considered “existing” and must be protected, regardless of whether or not the use activity has actually occurred.

Figure 3-1 shows the generalized methodology used in this UAA process. The methodology relies on the identification and evaluation of specific indicators and measures that represent salient characteristics of a given use as defined by the standards. Through analysis of these measures, and comparison of those measures with known minimum criteria, thresholds, or requirements needed to support that indicator, an assessment has been made as to the existence of each use. Explicit in these analyses is a determination of specific waterbody attributes that are either conducive to attaining or preventing a given use. These attributes are evaluated to determine if certain modifications or controls would allow the use to be attainable and, if so, the feasibility or reasonableness of those options.

3.1 Methodology Steps

Step 1: Is the designated use being attained?

A beneficial use that is currently being attained, or that is demonstrated to have been attained anytime on or after November 28, 1975 (the date on which the Federal Water Quality regulations took effect), is defined as an “existing use”. A beneficial use that is defined as an existing use is evidence that the use is occurring or that water quality is sufficient to allow the use to occur. An existing designated use may not be removed.

Step 2: Is water quality sufficient to attain the beneficial use?

A beneficial use that is not demonstrated to be existing does not preclude a waterbody from being in attainment. For example, a waterbody that is not being used as a drinking water supply source may be of sufficient quality and quantity to be a future source of drinking water. In this case, the beneficial use is being attained (although it is not being used) and that beneficial use may not be removed from the waterbody.

Therefore, for beneficial uses not demonstrated to be present on or after November 28, 1975, the UAA evaluated the types of indicators most appropriate for subsequent evaluation of each designated use. The UAA compiled the characteristics of the waterbody and its surrounding watershed, including water flow conditions, natural water quality, human-made water quality, physical habitat conditions, and human-made physical alternations. For each use, there is a separate set of conditions necessary for the use to be attainable.

Information elements in Table 3-1, were compared with criteria or “threshold values” to determine whether each indicator is supported and the use is attainable. Measures used and results of these analyses are presented for each beneficial use in subsequent Chapters of this report. After data were evaluated, an assessment was made as to whether each use is attainable.

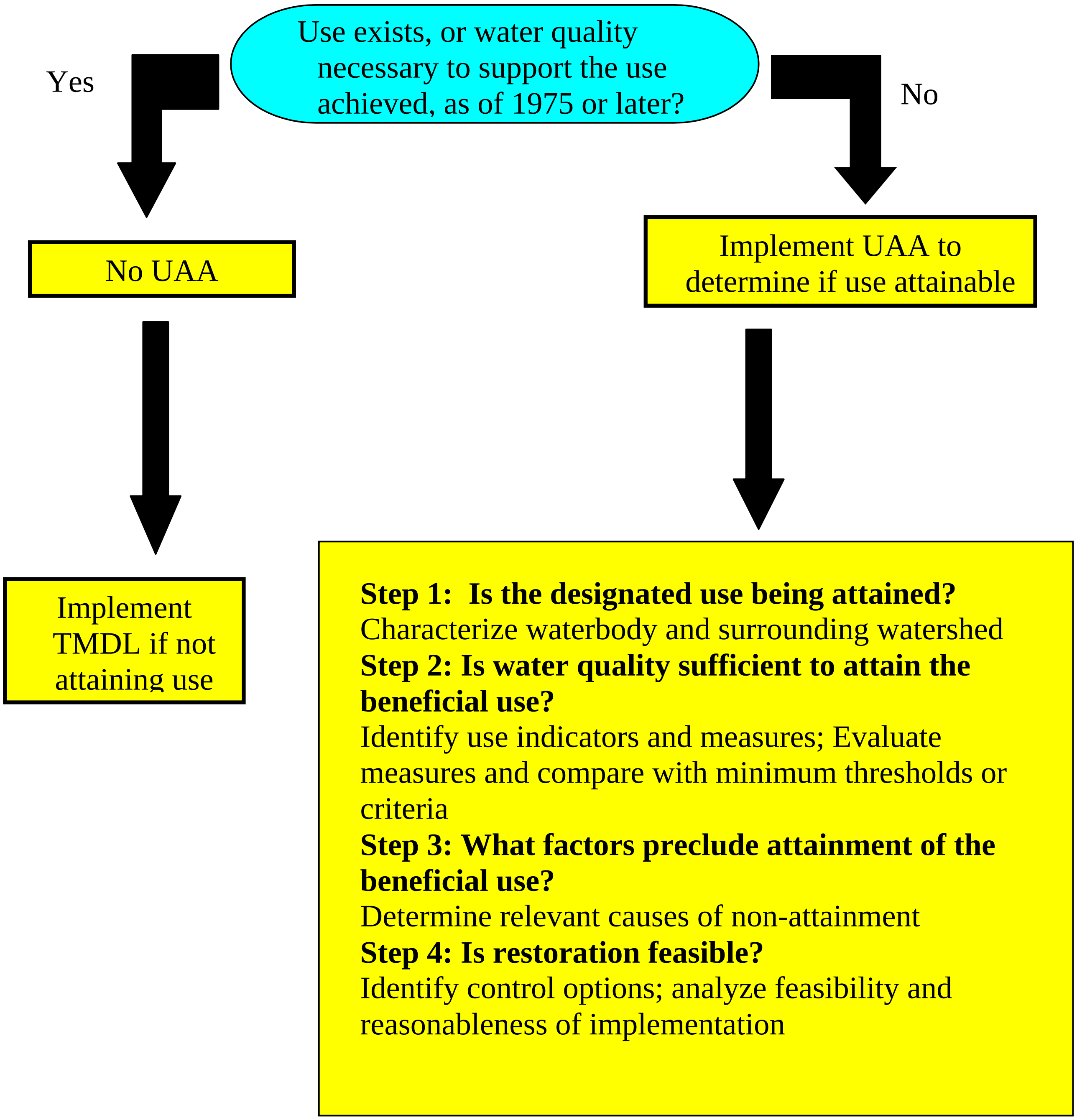


Figure 3-1. Summary of steps evaluated for each beneficial use assessed in the UAA.

Table 3-1. Summary of information elements evaluated in the UAA, by category of 131.10(g) factor.

Category	Information Elements
Water Flow Conditions	• Effluent flow within segment (seasonal flow patterns, maxima, minima) • Sources of water to the segment
Natural Water Quality	• This category was not examined because most of the flow originates from human-made sources.
Natural Physical Conditions	• Prevailing water and air temperatures • Aquatic life habitat (benthos, fish, plants) within the segment (includes riparian and stream habitat characteristics)
Human-made Physical Alterations	• Type and number of dams and other structures that alter flow or water velocity in the segment • Type and number of water diversion and other intake structures in the segment
Human-made Water Quality Conditions	• Human sources of potential water quality stressors in segment

Decision trees were developed for each beneficial use examined in this UAA that present the process used to determine whether a beneficial use is attainable. These decision trees are discussed for each use in respective chapters of this report.

Sources used to evaluate characteristic elements for each use included:

SWRCB and RWQCB reports and permit reviews (SWRCB/OCC File A-1375, 2002)
fish and macroinvertebrate data collection activities
aquatic life habitat analyses
Contacts with State agency staff, wastewater dischargers, irrigation district staff, and others in the region.
Site-specific data collected by other organizations (RBI, 2002a, b).

The following briefly summarizes the rationale for each element presented in Table 3-1.

Water flow conditions. The quantity and consistency of water flow are critical components for stream aquatic life (Hynes, 1970; Vannote et al., 1980; Statzner et al., 1988; Merritt and Cummins, 1996), particularly for many California fish species (Moyle and Baltz, 1985; Marchetti and Moyle, 2001), as well as for public water supplies (i.e., MUN use).

Typical flow patterns and the sources of water to the waterbody segment were evaluated as a characteristic of the waterbody. For effluent-dominated waters, much, if not all the flow is a result of human-made sources.

Natural water quality. An understanding of the natural physico-chemical water quality is necessary for evaluating whether there are natural constraints on beneficial uses such as drinking water quality (MUN) or aquatic life uses (COLD, SPWN, and WARM). For example, in some cases (e.g., certain geothermal springs in the Lahontan region of California; Unsicker, 2000), natural physicochemical properties may be lethal or chronically toxic to aquatic life indicative of a certain use, or a threat to public health as a water supply. For effluent-dominated waters, water quality is largely driven by human-made sources (i.e., treated effluent).

Natural physical conditions. The physical aspects of a waterbody can dictate the types of aquatic life that can be present. The natural physical structure of the stream, such as sediment particle size and geology, along with flow conditions, have a large effect on the types of aquatic life that can be expected to occur (Hynes, 1970; Bell, 1973; Reice, 1980; Minshall, 1984). For certain species, the prevailing water temperature is a chief driver affecting distribution and abundance (Sweeney, 1984; Bell, 1973). Many types of aquatic life are mobile (e.g., fish) and/or have complex life cycles that require different habitat types to reproduce and persist (e.g., aquatic insects).

Human-made physical alterations. Various human-made alterations to the natural stream channel, the riparian zone, or the flow of water through the segment can have profound effects on the types of aquatic life that can occur (WDFW, 1999; Hooper, 1973; Ward and Stanford, 1979; Baltz and Moyle, 1993; Brown, 2000) and the degree to which a public water supply is feasible or attainable. Information related to the types of human-made alterations, including barriers, dams, water diversions, intake structures, and physical habitat is therefore a critical element of this information category.

Human-made water quality conditions. Water quality conditions as a result of human impacts can be traced to land use in the watershed and to the discharge of treated wastewater directly into the waterbody. Human-made water quality conditions include toxicity due to chemicals, introduction of pathogens, and physical changes such as low dissolved oxygen, sedimentation, or temperature. The degree to which these water quality impacts limit attainability of a use depend on the specific beneficial use and the limiting factors of those uses. For aquatic life uses examined in this UAA, temperature, dissolved oxygen and physical habitat are the major water quality factors examined because aquatic species tend to have specific well documented requirements for these parameters. Many other water quality parameters are also potentially important including pH, dissolved solids, and chemical contaminants such as pesticides and nutrients. For MUN, pathogen and contaminant concentrations are particularly relevant.

Effluent-dependent waterbodies (EDW) such as Old Alamo Creek, represent one (albeit common) type of surface water situation in the Central Valley of California, for which state and federal water quality standards and regulations apply. Because this type of waterbody represents certain unique hydrologic characteristics, the UAA framework can be further streamlined or tailored towards addressing beneficial use issues specific to these waterbodies. For EDWs, much if not all the flow, and the prevailing stream water quality, is associated with treated effluent quality or human-made sources. Therefore, to a certain extent, water quality in an EDW is controllable by further modifying wastewater treatment and subsequent effluent quality. For example, some parameters, such as temperature, may currently limit the attainment of an aquatic life use (such as COLD) but not necessarily the *attainability* of that use as it may be feasible to control such parameters. Thus, existing water quality conditions can not necessarily be used to justify removal or de-designation of a beneficial use, unless such conditions can not be remedied or would cause more environmental damage to correct than to leave in place (see CFR factor (3), at the beginning of this Chapter).

Step 3: What factors preclude the attainment of the beneficial use?

If analyses indicated that waterbody conditions have not met minimum thresholds for a particular use, the causes for non-attainment were then evaluated. This is akin to a stressor-identification evaluation (USEPA, 2000). The stressor-identification process uses a weight-of-evidence approach to determine the likely causes of an observed environmental effect. In this analysis, conceptual models or flowcharts (such as those presented later in this report for each use) are used to highlight significant relationships between potential stressors (e.g., water quality, hydrological modifications) and the indicators of the beneficial use. These conceptual models resemble those used in a risk assessment (USEPA, 1998) in which site-specific data and scientific literature are evaluated to test the strength of potential cause-effect relationships.

Data collected under Step 2 of this framework were combined with available literature information for the region to identify likely stressors (causes) affecting attainability of a beneficial use. The relative strength of each cause-effect relationship was then determined by considering the degree to which the indicator measurements differed from minimum thresholds needed to attain the beneficial use. For aquatic life uses, such as COLD, SPWN, and MIGR, comparisons between measured values and thresholds could be quantitatively determined in part using fish habitat suitability indices (HSIs) and their various component values. The greater the disparity between the measured HSI component value for a given environmental factor (e.g., sediment particle size) and the minimum threshold, as defined by the HSI, the more limiting that particular factor is in preventing attainment of the use. These quantitative assessments were supplemented with qualitative evaluations for those indicators lacking threshold values.

A weight-of-evidence approach was used to synthesize results of the conceptual model approach to determine overall attainability of a beneficial use. More consistency in results among indicators (e.g., all indicators demonstrate a low probability of beneficial use attainment), would mean a higher degree of certainty in the overall assessment regarding use attainability. Where indicator results are not entirely consistent, more weight is given to factors for which minimum threshold criteria are well-established and documented in the peer-reviewed literature. As mentioned above, the poorer a particular factor actually is, in comparison with minimum threshold criteria, the more limiting that factor is in attaining the use and therefore, the less likely is use attainment. The more factors that do not meet minimum threshold criteria, the more certain that the use is not attainable.

Step 4: Is restoration feasible?

Once the major stressor(s) were identified, the UAA evaluated the types of controls or potential mitigation that would be needed to attain the use. The feasibility of these options was explored in a qualitative manner.

Human-made water quality (i.e., treated effluent) is considered a controllable factor. Any potential water quality constraint identified for a given use is considered in light of whether current effluent treatment contributes to that constraint, and can therefore be feasibly restored. Current effluent and stream water quality conditions are not an indication of conditions that are attainable but rather conditions that are currently attained. For non-altered or more natural waterbodies, a determination of attainable water quality conditions is fairly straight forward through a comparison with "reference" or least impaired conditions for similar waterbodies in the same ecoregion or waterbody class (e.g., elevation, drainage area). Water quality conditions in reference waterbodies represent attainable water quality conditions relevant to a given use and a measure of whether certain water quality factors are controllable. For modified waterbodies, such as EDWs or agricultural drains, the analysis is much less clear because reference conditions are not readily identifiable.

For this UAA, existing water quality conditions, in and of themselves, were not limiting attainability of any beneficial use examined in Old Alamo Creek although in some cases they may indicate that a use does not currently exist. Where a given beneficial use was determined to be unattainable, other factors (hydrologic and physical factors) were identified as more important or ultimately preventing beneficial use attainability. Therefore, detailed wastewater treatment engineering or economic analyses were not necessary in this Step.

4. Data Collection

4.1 Physical Habitat Collection Methods and Results

4.1.1 Physical Habitat Assessment

Two physical habitat investigations were conducted by Tetra Tech, Inc. in August 2002 and January 2003 to evaluate both warm (dry) and cold (wet) season habitat conditions (see Appendix A for methods). Habitat and biological sampling was performed at a total of 11 locations in the Creek (see Figure 4-1). Physical habitat parameters, including substrate size and type, velocity, canopy cover, riparian zone, and instream habitat, were measured using the Wolman pebble count (Wolman, 1954), Rapid Bioassessment Protocol (Barbour et al., 1999), and visual observation. The modified Wolman pebble count consisted of 10 blind measurements of substrate particle size, from bank full to bank full, at 10 transects within each reach. Transects were proportionally distributed among the stream features (e.g., riffles, runs, pools). Velocity was measured using a digital flowmeter at three locations, thalweg and one-half the distance from thalweg to each bank, across each modified Wolman pebble count transect. Percent cover was measured at the thalweg in each transect facing in all directions using a convex densiometer.

Detailed stream temperature and dissolved oxygen data were supplied by the City of Vacaville (RBI, 2002a,b) in addition to the data collected in the two fish and habitat surveys. Temperature was sampled over a one-year period (October, 2001 – August, 2002) in 10 locations, 2 upstream of EWWTP and 8 locations downstream. Diurnal oxygen monitoring was conducted by RBI during November, 2001, and March, July, and August, 2002 at 12 stations, 2 upstream of EWWTP discharge, and 10 downstream, including the wastewater discharge.

Ten parameters describing physical habitat quality and stability were visually assessed at each site in Old Alamo Creek (see Table 4-1), following the categories outlined in EPA's habitat assessment protocols (Barbour et al. 1999). These parameters were ranked as optimal, sub-optimal, marginal, or poor based on a 20 point scale, with 20 being the best possible (optimal) conditions. A reference database, and thus, a degraded/non-degraded threshold has not been developed in California to allow direct comparison to physical habitat characteristics. For this reason, the values were summed and compared to the maximum possible score (200) to provide a relative comparison for each site. The final three parameters evaluate each bank separately. The range of scores for each bank is 0 (poor) to 10 (optimal).

4.1.2 Aquatic Habitat

Current Velocity

Average current velocities for each sampling location are summarized in Table 4-2. The sites upstream of the EWWTP discharge (OA1 – OA5) have limited flow and are dominated by standing pools with no surface hydrologic connection to each other or downstream, and therefore, very low current velocity. Average velocities downstream of the EWWTP discharge (sites OA6 to OA11) ranged between 14.9 (August) and 87.8 cm/s (Winter).

Table 4-1. Summary of aquatic life habitat assessment parameters evaluated at each sampling location in Old Alamo Creek. (Abbreviations for each habitat parameters shown in parentheses correspond to the parameters shown in Figure 4-1.)

Habitat Parameter	Definition
Epifaunal substrate/available cover (EPI)	Includes the relative quantity and variety of natural structures in the stream, such as cobble (riffles), large rocks, fallen trees, logs and branches, and undercut banks, available as refuge, feeding, or sites for spawning and nursery functions of aquatic macrofauna.
Pool substrate characterization (PSC)	Evaluates the type and condition of bottom substrates found in pools.
Pool variability (PV)	Rates the overall mixture of pool types found in streams, according to size and depth.
Sediment deposition (DEP)	Measures the amount of sediment that has accumulated in pools and the changes that have occurred to the stream bottom as a result of deposition.
Channel flow status (CFS)	The degree to which a stream is filled with water.
Channel alteration (CA)	Measures large-scale (usually anthropogenic) changes in the shape of the stream channel.
Channel sinuosity (CS)	Evaluates the meandering or sinuosity of the stream. A high degree of sinuosity provides for diverse habitat and fauna, and the stream is better able to handle surges when storms create fluctuations.
Bank stability (BSL and BSR)	Measures whether the stream banks are eroded (or have potential for erosion).
Vegetative protection (VPC and VPR)	Measures the amount of vegetative protection afforded to the stream bank and the near-stream portion of the riparian zone.
Riparian vegetative zone width (RZL and RZR)	Measures the width of natural vegetation from the edge of the stream bank out through the riparian zone.

Table 4-2. Average current velocities (cm/s) recorded at each sampling location in Old Alamo Creek in August and January. See Figure 2-2 for site locations.

	Site										
	OA1	**OA2**	**OA3**	**OA4**	**OA5**	**OA6**	**OA7**	**OA8**	**OA9**	**OA10**	**OA11**
JANUARY											
Average Velocity (cm/s)	0	0	0	0	0	55.4	76.7	38.9	87.8	75.0	75.6
AUGUST											
Average Velocity (cm/s)	0	0	0	0	3.43	NA	27.1	26.4	27.8	14.9	21.9

Substrate

The substrate of Old Alamo Creek is dominated by the natural sand and silts common in soils of the Central Valley. The substrate upstream of EWWTP (sites OA1 – OA5) was comprised of 100% silt/clay while sites downstream of EWWTP were a mix of silt, clay and sand (Table 4-3).

Table 4-3. Summary of Wolman pebble count analysis of benthic substrate at each site in Old Alamo Creek. Numbers represent percent of sediment in each size class.

Substrate Type	OA1	OA2	OA3	OA4	OA5	OA6	OA7	OA8	OA9	OA10	OA11
Silt/clay (<0.062 mr	100	100	100	100	100	79	47	20	68	100	86
Fine sand (0.062-0.	-	-	-	-	-	21	13	80	-	-	
Med sand (0.25-0.5	-	-	-	-	-	-	40	-	30	-	
Course sand (0.5-2	-	-	-	-	-	-	-	-	2	-	
Small gravel (2-16)	-	-	-	-	-	-	-	-	-	-	12
Large gravel (16-64	-	-	-	-	-	-	-	-	-	-	
Cobble (64-256)	-	-	-	-	-	-	-	-	-	-	
Boulder (2 > 256)	-	-	-	-	-	-	-	-	-	-	2

Habitat Assessment

The stream channel and riparian zone below the "headwaters" of Old Alamo Creek at sampling stations OA1 – OA5 have retained their natural structure however the stream channel is dry for most of the year (see Appendix A). Disconnected pools were observed in the channel from small irrigation return flows. There is no current in the channel and the substrate is entirely silt with little cover for aquatic life, resulting in relatively low habitat scores (Table 4-4).

Sampling sites OA 6 – OA 9, downstream of the EWWTP discharge, have year round flow resulting in more current velocity and greater overall cover. Large woody debris and root wads are primary habitat components throughout this part of Old Alamo Creek above site OA 6 (see Appendix B). The narrow stream here has a dense riparian canopy and the stream channel is composed primarily of runs (~90%) with a few small pools, resulting in some of the highest habitat scores in the creek (Table 4-4).

Within a short distance downstream of site OA 9 the stream has been channelized and the riparian corridor is intensively managed, removing any of the habitat components present in the upper portions of the channel. The lack of channel sinuosity, riparian vegetation, and cover, combined with nearly homogeneous fine particle size substrate, resulted in the lowest habitat scores in the Creek (see Appendix B; Table 4-4). These conditions persist to the confluence with New Alamo Creek and on to the confluence with Ulatis Creek. Overall, Old Alamo Creek aquatic life habitat appeared to be limited by poor riparian corridor quality (vegetation, bank stability), lack of channel sinuosity, limited pool quality and sediment deposition to the stream particularly downstream of site OA 5 (Figure 4-2).

Temperature and Dissolved Oxygen

Data provided by RBI (RBI, 2002a) from October 2001 to August 2002, indicate that the seasonal temperature regime of Old Alamo Creek is dictated by the EWWTP discharge (see Figure 4-3). For much of the winter and spring, the EWWTP outfall and the closest downstream site had the highest temperature with a progressive decrease downstream. Summer water temperatures were more similar across sites. Thus, during the cooler months, agricultural inputs downstream of Fry Road appeared to have a slight cooling effect on the temperature of Old Alamo Creek (Figure 4-3). Maximum temperatures recorded during the one-year RBI study were 27° C in July and August and average temperature for all sites was approximately 26° C for the period June – August (Figure 4-3). Temperatures did not get below 16° C at any site during this study.

Table 4-4. Total physical habitat quality assessment scores for Old Alamo Creek in August, 2002 and January, 2003.

Station ID	Date Collected	Total Habitat Score	% of Maximum Habitat Score (200)
OA 1	08/27/2002	88	44
	01/09/2003	103	51.5
OA 2	01/09/2003	126	63
OA 3	08/28/2002	62	31
	01/08/2003	112	56
OA 4	01/08/2003	126	63
OA 5	08/27/2002	77	38.5
	01/09/2003	91	45.5
OA 6	01/09/2003	107	53.5
OA 7	08/28/2002	123	61.5
	01/08/2003	81	40.5
OA 8	08/28/2002	106	53
	01/16/2003	91	45.5
OA 9	08/28/2002	67	33.5
	01/08/2003	68	34
OA 10	08/28/2002	40	20
	01/08/2003	79	39.5
OA 11	08/28/2002	56	28
	01/08/2003	64	32

RBI data (RBI, 2002b) indicated that both the daily average and the minimum DO concentrations in Old Alamo Creek generally increased beginning 150 foot downstream of the EWWTP outfall to the confluence with New Alamo Creek (Figures 4-4 and 4-5).
Average DO concentrations were ≥ 6 mg/L in all seasons and all sites and varied little across months for a given site (Figure 4-4). Minimum dissolved oxygen levels at each site followed a similar pattern but were < 5 mg/L in the most downstream site in August and in several upper sites in November (Figure 4-5). The lowest minimum oxygen level recorded in this survey was 3.9 mg/L, just upstream of the confluence with New Alamo Creek in August.

4.2 Aquatic Life Sampling Methods and Results

4.2.1 Fish Sampling

Two fish surveys were performed, one in August and one in January, at the 11 sites in which habitat information was collected (Appendix A). The purpose of these surveys was to sample all available habitats in an attempt to collect all species present. These surveys were not used to assess quantitative fish population metrics. Fish were captured using electrofishing gear, with two passes made at each site. Fish were collected via a pulsed direct current backpack electrofisher. The collection proceeded in an upstream direction from the downstream end of the targeted reach. Stunned fish were netted, identified and released except for young or unidentifiable specimens. Specimens that couldn't be identified with certainty in the field were preserved in 10% formalin solution and later identified in the laboratory.

4.2.2 Fish Sampling Results

No cold-water fishes were captured at any of the sites surveyed (Table 4-5). *Gambusia affinis* (mosquitofish) an exotic species, was the dominant fish captured. Fathead minnow, threespine stickleback, Sacramento sucker, Tui chub, and Sacramento pikeminnow were also collected. All except fathead minnow are indigenous to the region (May and Brown, 2000) and all of the species collected are characteristic of warm-water streams (Lee, 1980; Page and Barr, 1991; May and Brown, 2000).

During both the summer (August) and winter (January) sampling events, young-of-the-year fish were found. In August, young-of-the-year mosquitofish and gravid females were found in some sites, along with fathead minnows captured with breeding tubercles and coloration indicative of spawning. During the winter sampling, young-of-the-year mosquitofish were found in abundance throughout the creek, as well as young-of-the-year Tui chubs and three-spine sticklebacks. A similar number of fish was collected during both the August and January surveys and the same species were collected at both times. The most upstream sites (OA1 and OA2) surveyed resulted in only one mosquitofish captured.

4.2.3 Habitat Suitability Indices

Temperature, dissolved oxygen, and physical habitat data reported in previous sections were used in Habitat Suitability Index (HSI) calculations for cold-water fishes, including rainbow and steelhead trout, and chinook salmon, and for several warm water fish species.

Physical habitat and food availability information were used, in conjunction with the HSI curves and models, to generate an HSI score for each species. The HSI is a rating of the habitat with 1 being optimal habitat and 0 being unsuitable habitat (USFWS, 1981). Most HSIs are based on several different resource components including water quality, food, cover and other physical habitat features, as well as different life stages including adult, juvenile, fry, and embryo. The individual parameters are used in a weighted formula to determine the component scores, which in turn are aggregated to determine the overall HSI (see Appendix C for more detailed description of the methodology and specific components for each HSI examined). The species life stage, and its associated water quality and habitat factors, were identified based on the specific beneficial use examined. For example, for the SPWN use, habitat factors pertaining to early life stages (e.g., egg, larvae, fry) are the focus of HSI analyses. Data used in these analyses were derived from data collected at or close to the critical time period specified in the particular species HSI; e.g., winter data were used for winter spawning species.

HSIs are useful for delineating upper and lower tolerances of a species to various environmental factors, and therefore provide a reasonable approximation of threshold criteria that could be used along with other information to evaluate beneficial use attainability. Although based on extensive scientific literature and experimental studies, an HSI value computed for a particular site may or may not be an accurate reflection of a species ability to survive in that location. Site-specific factors or genetic adaptations within a given subregion may modify a species' ability to tolerate what are otherwise inhospitable conditions according to the HSI. However, if several or all components of an HSI indicate very poor conditions (i.e., suitability indices < 0.3), there is a high likelihood that the habitat at the site can not sustain a given life stage or stages of the species.

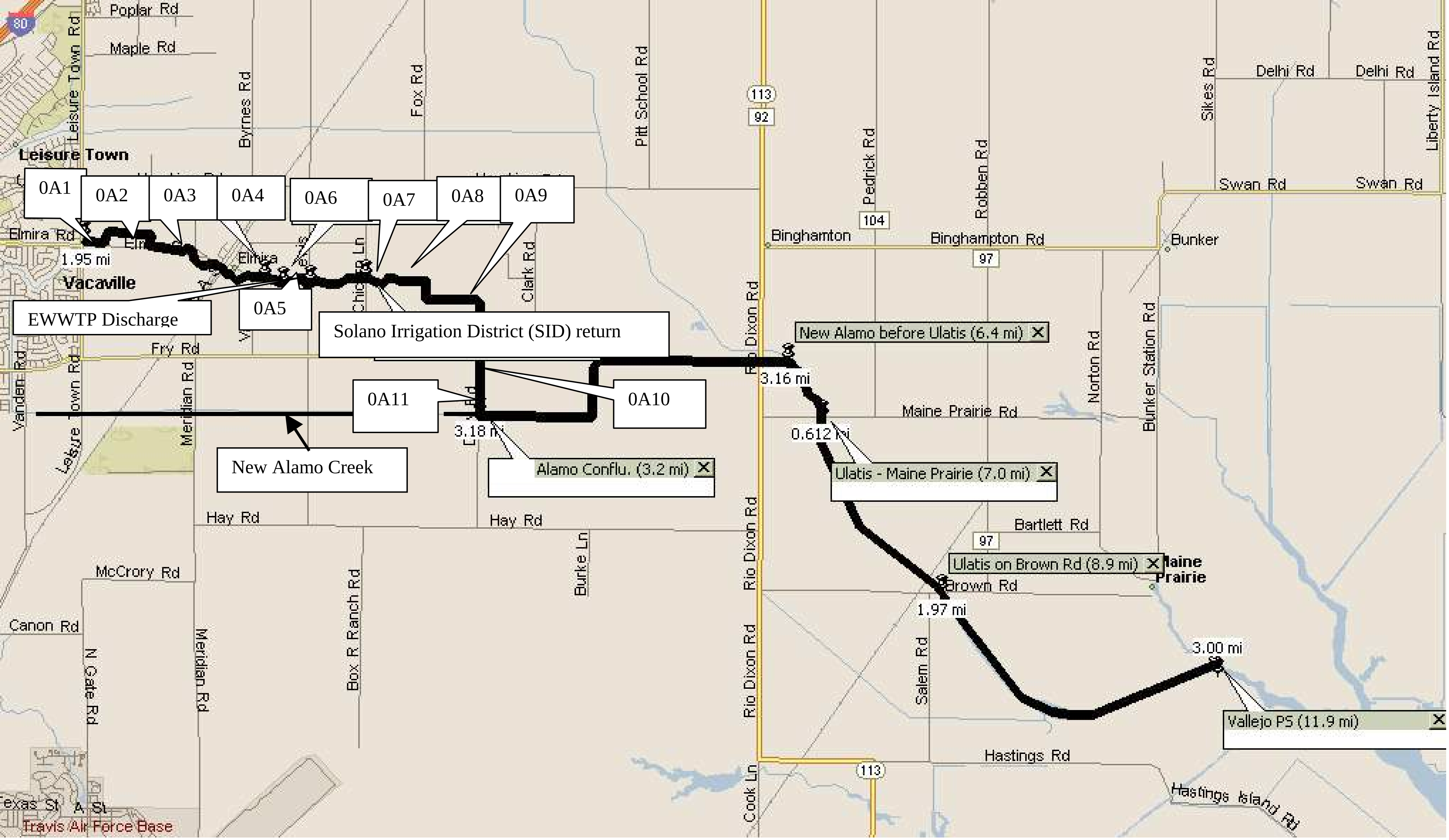


Figure 4-1. Map showing the sampling locations used in the UAA to characterize habitat characteristics and aquatic biota.

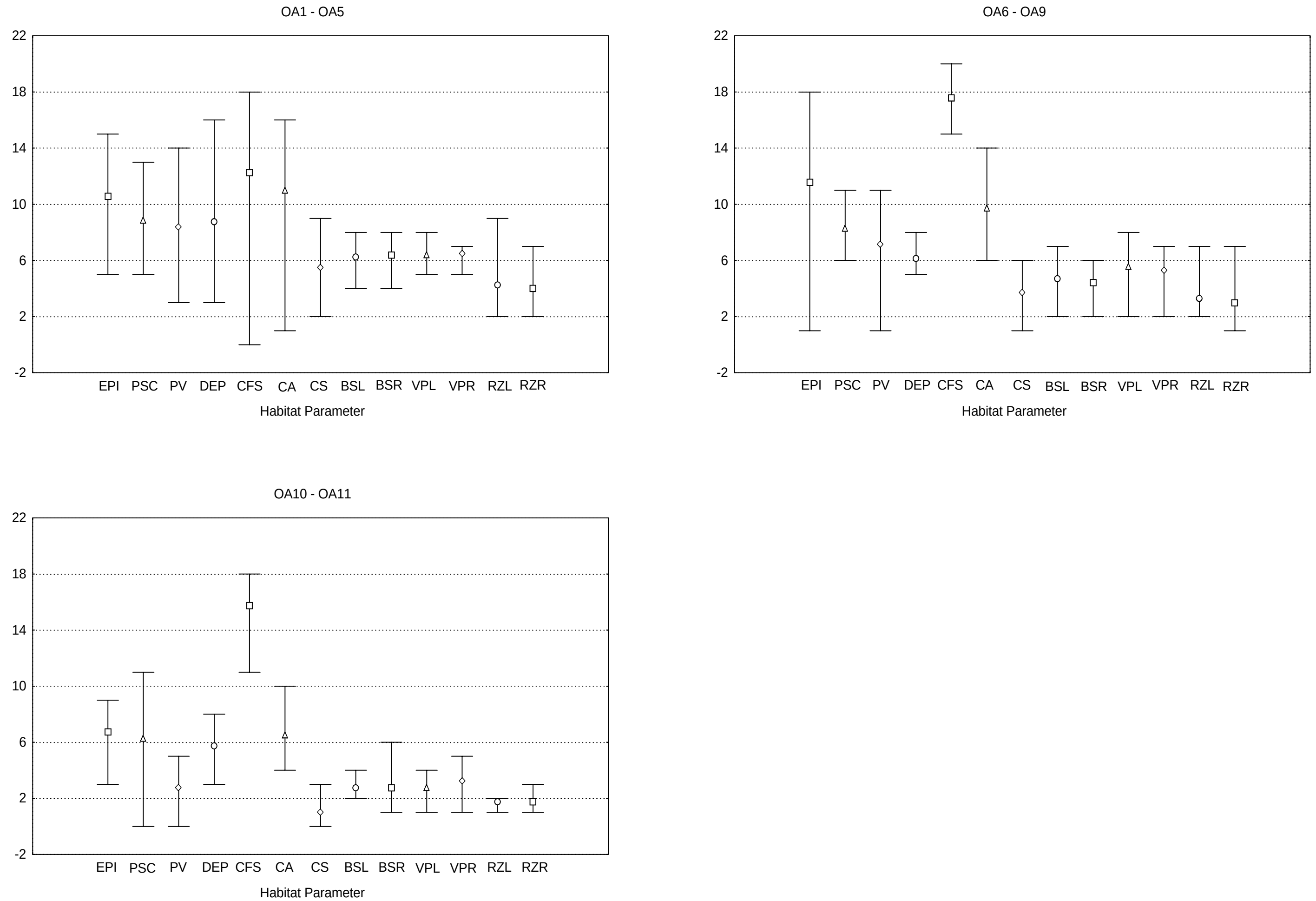


Figure 4-2. RBP habitat parameter results for the three segements in Old Alamo Creek. Upper Old Alamo Creek = OA1 - OA5; Middle Old Alamo Creek = OA6 - OA 9; and Lower Old Alamo Creek = OA10 - OA 11. See Table 4-1 for definitions of each habitat parameter abbreviation.

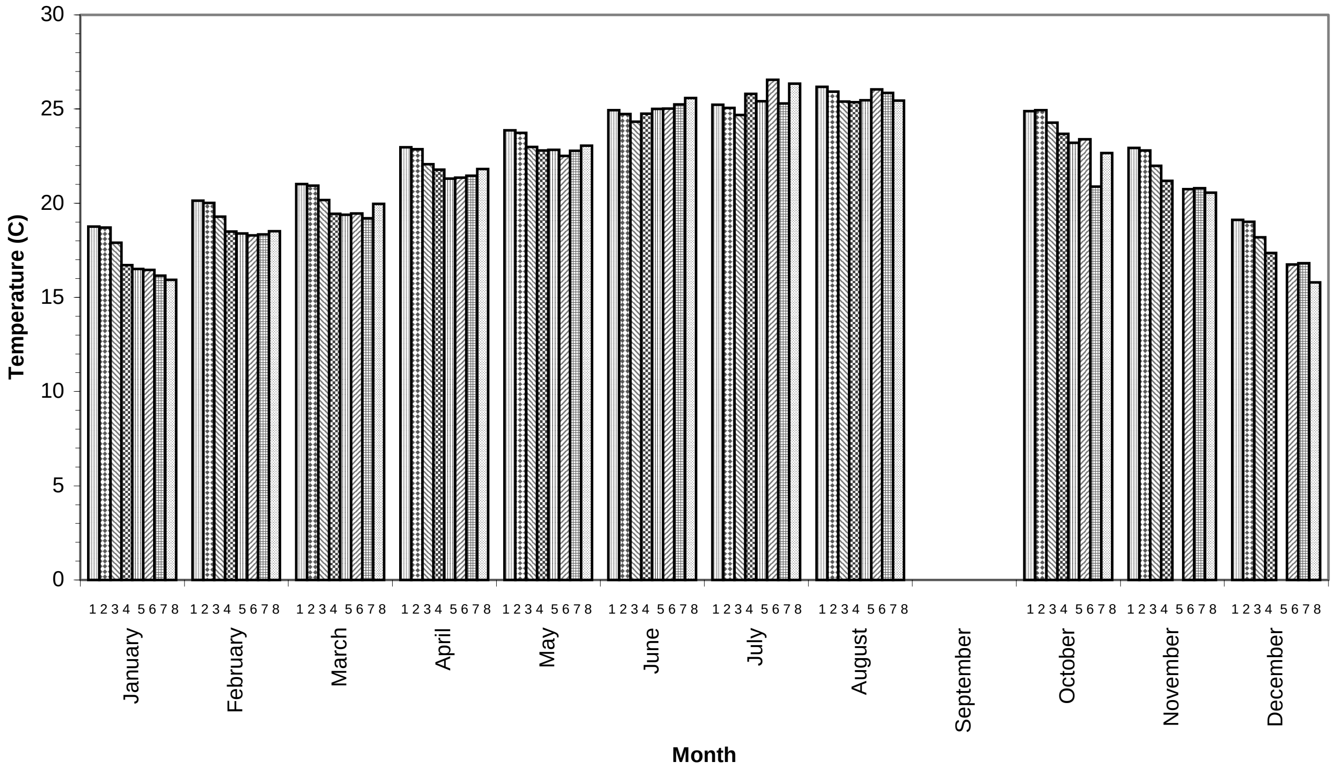


Figure 4-3. Average temperature in Old Alamo Creek (OAC) at various locations. 1 = EWWTP outfall; 2 = OAC at R-2; 3 = OAC at Chicorp Ln.; 4 = OAC Upstream of SID Canal; 5 = OAC Downstream of SID Canal; 6 = OAC Upstream of Fry Rd. Ag Drains; 7 = OAC Downstream of Fry Rd. Ag Drains; 8 = OAC Upstream of New Alamo Creek.

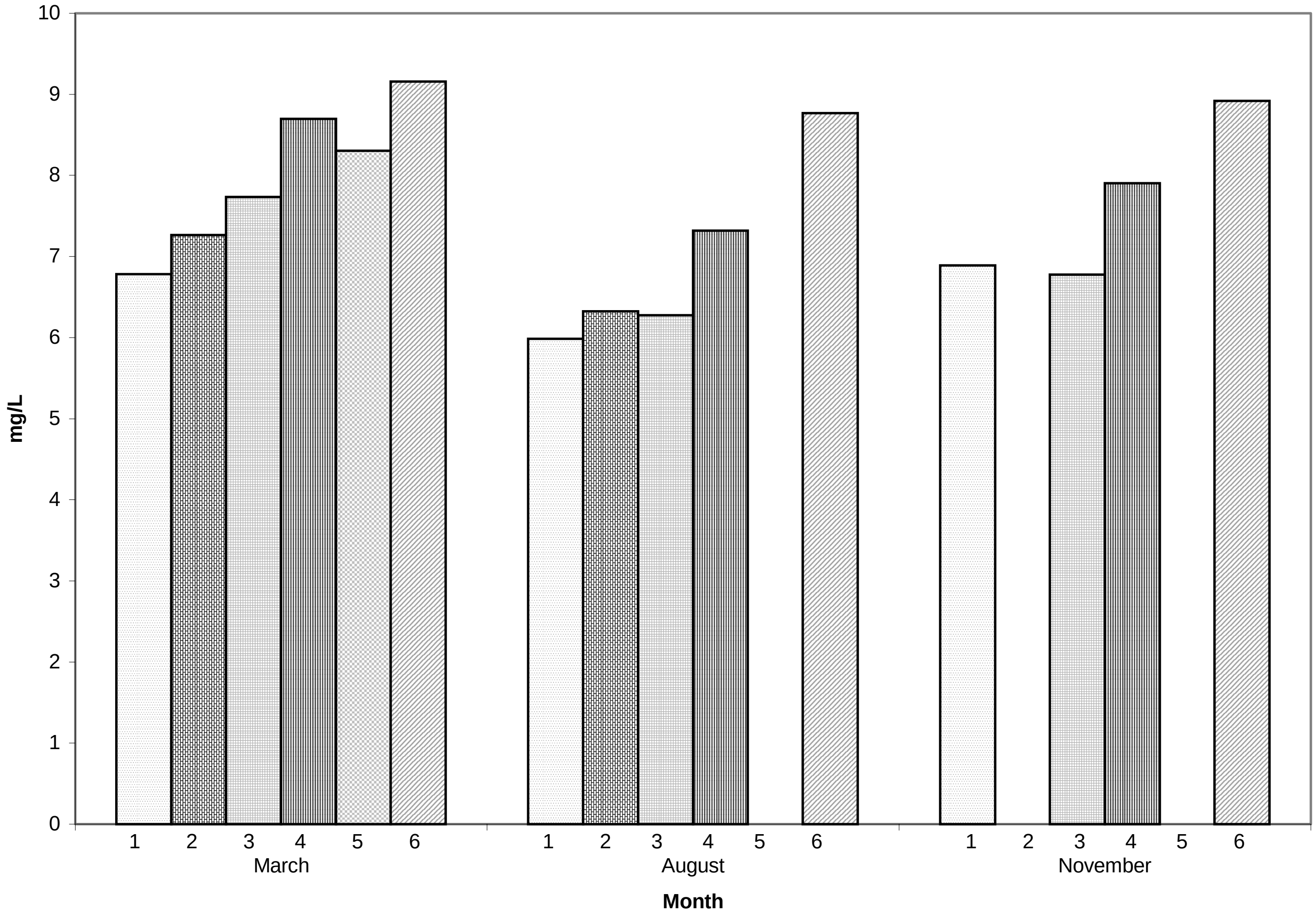


Figure 4-4. Average dissolved oxygen at various locations in Old Alamo Creek. 1 = OAC 150 ft downstream of EWWTP; 2 = OAC upstream of Lewis Rd.; 3 = OAC at Chicorp Rd. Bridge; 4 = OAC upstream of Fry Rd. Ag drains; 5 = OAC upstream of SID Canal; 6 = OAC upstream of New Alamo Creek.

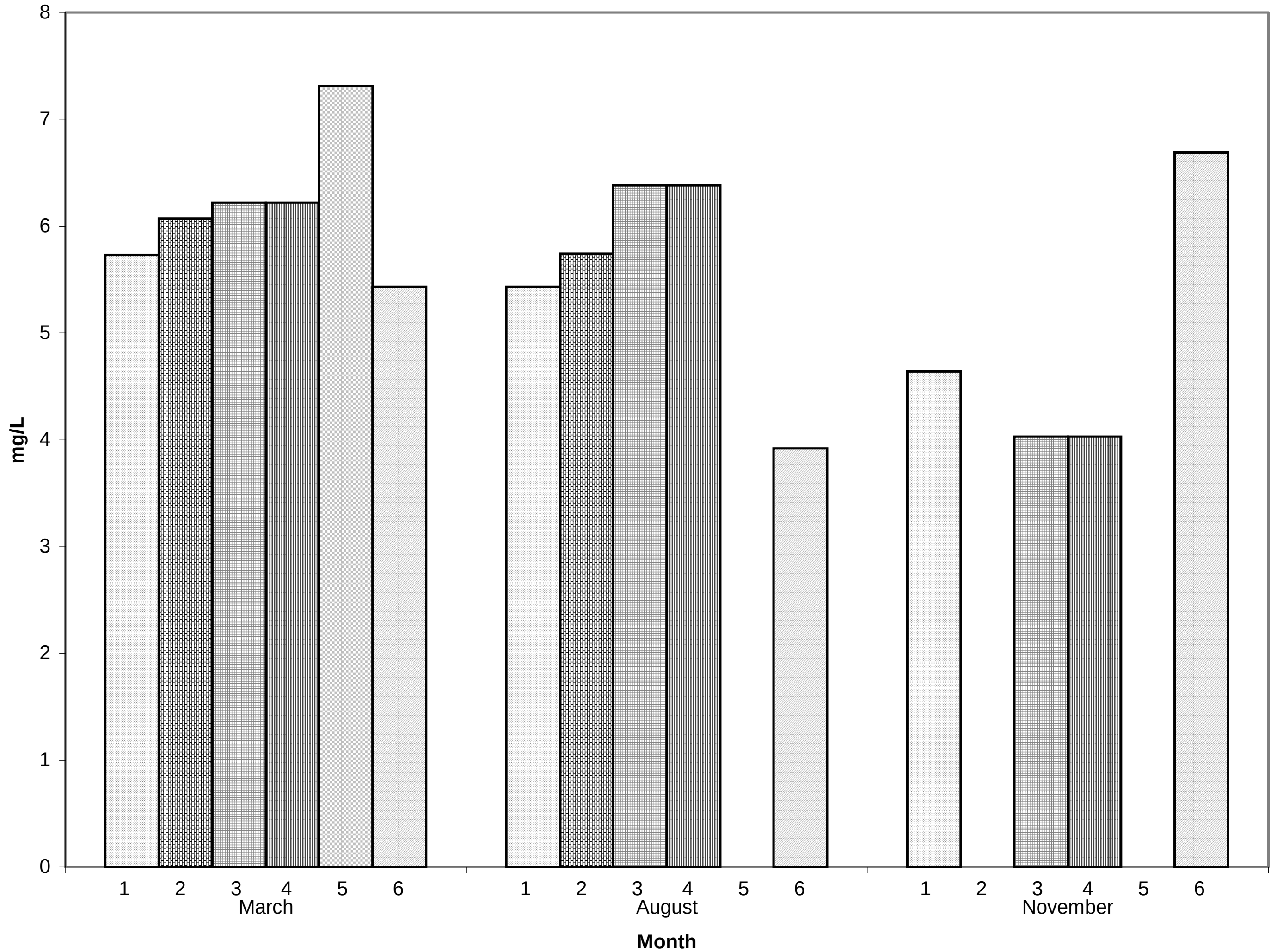


Figure 4-5. Minimum dissolved oxygen at various locations in Old Alamo Creek. 1 = OAC 150 ft downstream of EWWTP; 2 = OAC upstream of Lewis Rd.; 3 = OAC at Chicorp Rd. Bridge; 4 = OAC upstream of Fry Rd. Ag drains; 5 = OAC upstream of SID Canal; 6 = OAC upstream of New Alamo Creek.

Table 4-5. Results of summer (August 2002) and winter (January 2003) fish surveys at 11 sites in Old Alamo Creek.

Site	Date	Fish Species	Number
OA 1	1/15/03	No Fish Captured	0
	9/5/02	No Fish Captured	0
OA 2	1/15/03	Mosquitofish	1
	9/5/02	No Fish Captured	0
OA 3	1/15/03	Mosquitofish	15
	9/5/02	Mosquitofish Fathead minnow	2 3
OA 4	1/15/03	No Fish Captured	0
	9/5/02	No Fish Captured	0
OA 5	1/13/03	Mosquitofish Tui Chub	35 17
	9/5/02	Mosquitofish Fathead minnow Three-spine stickleback	82 27 4
OA 6	1/14/03	Mosquitofish	11
	9/5/02	Mosquitofish Fathead minnow	218 63
OA 7	1/15/03	Mosquitofish	10
	9/2/02	Mosquitofish Fathead minnow Sacramento pikeminnow Threespine stickleback	197 99 1 1
OA 8	1/16/03	Mosquitofish	24
	8/27/02	Mosquitofish Tui chub Sacramento sucker	267 7 2
OA 9	1/14/03	Mosquitofish Three-spine stickleback	221 1
	8/29/02	Mosquitofish Threespine stickleback Tui chub Sacramento sucker	158 6 2 1
OA 10	1/14/03	Mosquitofish Three-spine stickleback Fathead minnow Tui chub	27 19 2 4
	8/26/02	Mosquitofish Fathead Minnow Three-spine stickleback Sacramento sucker	152 6 5 9
OA 11	1/14/03	Mosquitofish Three-spine stickleback Fathead minnow	47 5 1
	8/26/02	Mosquitofish Fathead minnow Three-spine stickleback Sacramento sucker	110 8 9 26

5. Evaluation of Attainability for Cold Freshwater Habitat

The Cold Freshwater Habitat (COLD) beneficial use specifies conditions suitable to support cold water ecosystems including, but not limited to, preservation or enhancement of aquatic habitats, vegetation, fish, or wildlife, including invertebrates.

5.1 Step 1: Is the beneficial use being attained?

5.1.1 Background

The presence of cold water aquatic species, or any records of cold water aquatic species being present since November 28, 1975, would demonstrate that the COLD use exists. Discussions with the discharger and state agency personnel indicated that ecological studies of the site were not conducted previously. COLD use includes even temporary use or use by only certain life stages of cold water species. Under COLD use, the waterbody does not need to be capable of supporting the full life cycle of these species. In this vein, Maslin et al. (1999) report winter and spring rearing by juvenile salmonids in non-natal, intermittent streams in the Sacramento River drainage.

Contact with staff at the State and Regional Water Quality Control Boards, National Marine Fisheries Service, and California Department of Fish and Game indicated no evidence that the COLD use exists in Old Alamo Creek. No information is available to suggest that trout or other cold water organisms have been resident to Old Alamo Creek since 1975.

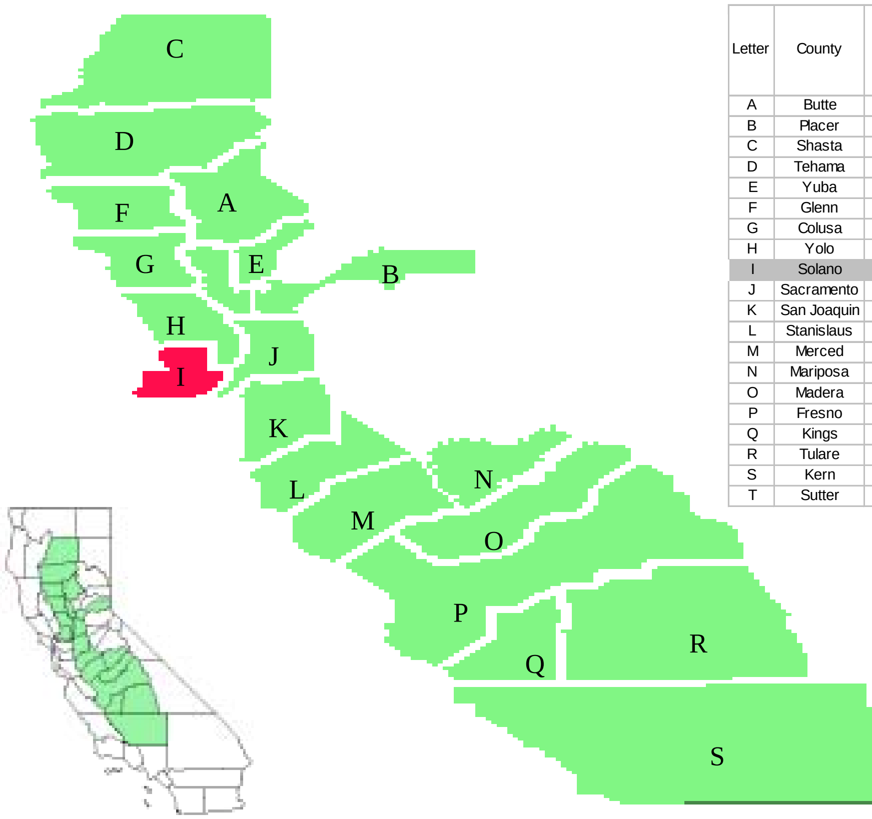
According to USGS records, there are at least eighty-three stonefly species and twenty mayfly species that occur in the Central Valley region of California (Kondratieff and Bauman, 2000). Of the eighty-three stonefly species, eleven of them are known to require cool water temperatures (<15ºC) year-round (USEPA, 1978a). One of the twenty mayfly species requires cooler water temperatures year-round (USEPA, 1978b). USGS records indicate that two stonefly species and no mayfly species have been reported in Solano County streams; the stonefly species are not obligate cold water species (Figure 5-1, Table 5-1). Cold water stoneflies or mayflies are very rare in valley bottom streams in the Central Valley according to USGS records (Domagalski et al, 2000) and sampling conducted by California Department of Fish and Game (CDFG, 1997, 1998, 2000). These species tend to occur in foothill streams of the Valley such as those in Shasta, Mariposa, and Madera counties (Figure 5-1).

5.1.2 Data Collected

Two fish surveys were performed, one in August 2002 and one in January 2003, at the 11 sites in which habitat information was collected (see Section 4.2, Chapter 4 and Appendix A).

5.1.3 Results

No cold water fish species were collected in either fish survey (Table 4-4, Chapter 4). *Gambusia affinis* (mosquitofish), an exotic species, was the dominant fish captured. Fathead minnow, threespine stickleback, Sacramento sucker, Tui chub, and Sacramento pikeminnow were also collected. All except fathead minnow are native to the region (May and Brown, 2000) and all of the species collected are characteristic of warm-water streams (Lee, 1980; Page and Barr, 1991; May and Brown, 2000).



Letter	County	# of Stonefly Taxa	Stoneflies Needing Temp. < 15 C	# of Mayfly Taxa	Mayflies Needing Temp. < 15 C
A	Butte	17	1	1	0
B	Placer	14	0	1	0
C	Shasta	33	6	5	0
D	Tehama	13	2	4	0
E	Yuba	0	0	0	0
F	Glenn	2	0	2	0
G	Colusa	5	0	2	0
H	Yolo	1	0	2	0
I	Solano	2	0	0	0
J	Sacramento	10	1	0	0
K	San Joaquin	0	0	0	0
L	Stanislaus	7	1	4	0
M	Merced	1	0	0	0
N	Mariposa	39	7	1	0
O	Madera	14	3	7	1
P	Fresno	14	1	1	0
Q	Kings	1	0	0	0
R	Tulare	13	1	2	0
S	Kern	6	0	1	0
T	Sutter	1	0	0	0

Figure 5-1. Number of Stonefly and Mayfly taxa collected in the Central Valley with emphasis on the obligatory cold water taxa (Kondratieff and Bauman, 2000).

Table 5-1. Ephemeroptera and Plecoptera species known to be present in Solano County (Domagalski et al, 2000).

Ephemeroptera Species of Solano County
No Species of Mayfly Reported
Plecoptera Species of Solano County
Suwallia autumna
Skwala americana

During both the summer (August) and winter (January) sampling events, young-of-the-year fish were found. In August, young-of-the-year mosquitofish and gravid females were found in some sites, along with fathead minnows captured with breeding tubercles and coloration indicative of spawning. During the winter sampling, young-of-the-year mosquitofish were found in abundance throughout the creek, as well as young-of-the-year Tui chubs and three-spine sticklebacks. A similar number of fish was collected during both the August and January surveys and the same species were collected at both times. The most upstream sites (OA1 and OA2 above the EWWTP discharge; Figure 2-2) yielded only one mosquitofish.

Based on the above data, there was no direct evidence of the COLD use being currently attained.

5.2 Step 2: Is water quality sufficient to attaining the beneficial use?

5.2.1 Background

Two measurable indicators were identified to evaluate attainability of COLD use: rainbow trout habitat and cold water stonefly (aquatic insect) habitat. Both rely in part on the water temperature regime, which was evaluated as well. The trout indicator was selected because it is a representative resident of cold water systems in California (Brown and Moyle, 1993) and their habitat requirements are relatively well known and measurable (USFWS, 1981; Raleigh et al., 1984). Few cold water fish species other than trout have been recorded in lowland Central Valley streams (McGinnis, 1984; Page and Barr, 1991; Domagalski et al., 2000). Habitat suitability indices (HSIs), developed by U.S. Fish and Wildlife Service (USFWS, 1981; Raleigh et al, 1984), and based largely on California information (Moyle et al., 1983), were used as specific measures for trout habitat quality and availability.

The stonefly indicator was selected because many of these species are representative of cold or cool water systems in California (Usinger, 1968) and their habitat requirements are relatively well known. While the ancestral habitat of all stream macroinvertebrates is believed to be cool streams, Hynes (1970a,b) suggested that taxa such as stoneflies occur in cool streams because these are survivors of primitive groups. Cold water stoneflies (and other cold water macroinvertebrates) are defined as species requiring < 15° C year-round. This temperature threshold was established based on USEPA's categorization of macroinvertebrate temperature tolerances as well as USEPA's whole effluent toxicity test protocols (USEPA, 2001), in which cold water species methods generally require test temperatures < 15° C.

In order for a waterbody to support the two cold water indicators selected, water quality and physical habitat parameters must have certain minimum characteristics. Water quality conditions fundamental to attaining COLD water use such as temperature and dissolved oxygen are intrinsically linked to the physical habitat of the streambed. The physical factors that are particularly significant for many types of cold water aquatic life are sediment particle size, riparian conditions, pool or cover quality, and current velocity. Figure 5-2 summarizes the environmental factors considered in the conceptual model to assess whether the habitat is sufficient to attain the COLD use. The following explains potential linkages between water quality or habitat factors and cold water indicators in the conceptual model.

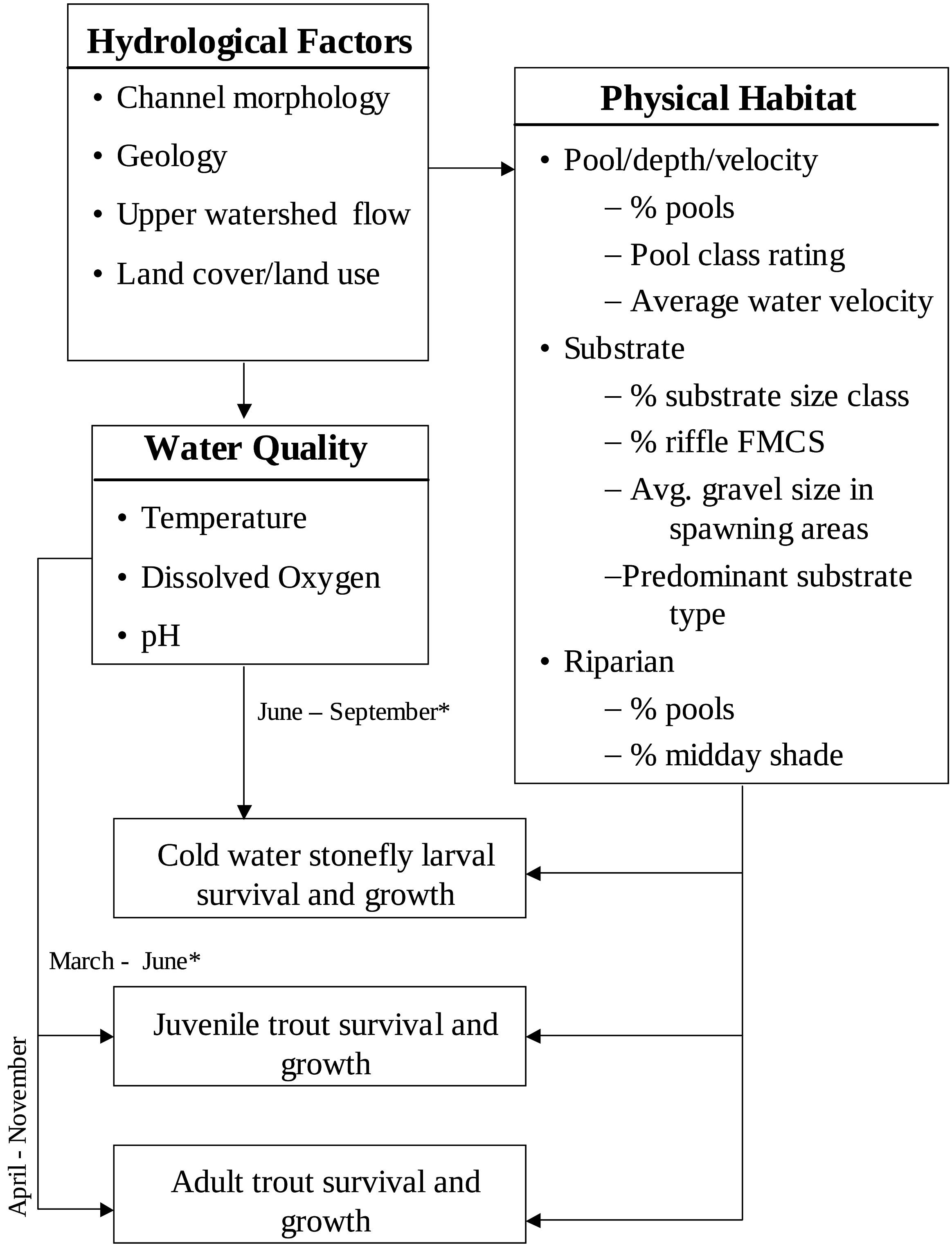


Figure 5-2. Simplified conceptual model illustrating key factors affecting attainment of COLD use. * = especially critical time period for temperature and/or dissolved oxygen requirements for the life stage noted.

Water Quality

Two water quality parameters, temperature and dissolved oxygen, are considered to be key factors limiting the attainability of the COLD use because cold water species have fairly narrow tolerance ranges for these parameters.

Temperature. Water temperature is determined by interactions between the amount of water flowing in the stream, the structural configuration of the stream, the riparian zone, and various factors external to the stream/riparian zone (USEPA, 2000). Fish and macroinvertebrates can be stressed or impaired by a number of factors, including temperature, at levels that do not actually kill the organism but that are outside the limits of normal performance and positive growth. Given the chance, fish and other aquatic organisms will select a combination of temperature, oxygen concentration, food availability, depth, etc., that is the best available compromise for survival and growth (Baltz et al., 1987). Temperature regime was examined because it is indicative of the ability of a stream to support cold water aquatic life (Ward and Stanford, 1982; Sweeney, 1984; May and Brown, 2000; McGinnis, 1984).

The conceptual model (Figure 5-2) depicts two limiting time periods for trout survival and population maintenance: March – June represents the time when embryo development occurs in this region and June – September, which represents the fry and juvenile growth period. The trout life stage most affected by temperature is the embryo, however all other life stages are indirectly affected by temperature (part of the “other” component of the trout HIS). These temperature requirements are expressed in the HSI as two temperature ranges providing minimal suitability (SI $\geq$ 0.3): 3-17^{o}C for embryos (optimal being 7-12^{o}C) and 2-23^{o} C for other life stages (optimal being 12-18^{o}C).

As invertebrates are poikilothermic (“cold-blooded”) organisms, their metabolic functions are also controlled largely by the ambient temperature. Aquatic macroinvertebrate development, feeding, and other life history functions are affected by water temperature (Sweeney, 1984). Much research has shown that temperature is an important cue for aquatic insect emergence timing (Sweeney, 1984). Those macroinvertebrates that live exclusively in cooler water, have adapted their life histories accordingly. For many of these species, the critical period is summer (June – September) when eggs and larvae are developing. Stoneflies that occupy warmer streams typically have multi-year life histories in which adults live and breed over more than one year (Sweeney, 1984; Stewart and Stark, 1988). A similar phenomenon is known for macroinvertebrates at different latitudes and elevations (Corbet, 1980; Brittain, 1978). Cold water adapted species do not have a summer estivation or diapause stage that would allow them to avoid or otherwise cope with hot summer conditions (Stewart and Stark, 1988). Instead, they have relatively slow but persistent growth year-round (Folsom and Manuel, 1983) and longer life cycles. In fact, many cold-water adapted macroinvertebrates such as some stoneflies, have relatively high winter detrital feeding activity in streams, coincident with the greater amounts of leaf litter as a food source at that time (Short and Ward, 1980). Cold water adapted invertebrates that are exposed to warmer water will emerge at inappropriate times, resulting in lethality of adults or lack of recruitment of young (Sweeney, 1984; Ward and Stanford, 1982). For cold water stoneflies, and many other cold water adapted macroinvertebrates, warm water tends to eliminate species rather than to permit alternate life cycles (Sweeney, 1984).

Dissolved Oxygen. Dissolved oxygen (DO) is critical to aquatic life survival, particularly for cold water species that are adapted to the higher oxygen saturation inherent in colder water (percent oxygen saturation is inversely related to water temperature). Sources of DO include aeration, inflow of turbulent water, and photosynthesis by aquatic plants. DO can be depleted through respiration (from aquatic life and algae), decay of organic matter, direct chemical oxidation, and outflow of water. The conceptual model (Figure 5-2) depicts a limiting time for trout during April – November, which represents the time when adult Rainbow trout would occupy the stream. Similar to temperature, dissolved oxygen is limiting in two components of the rainbow trout HSI: embryo and other life stages indirectly. The average minimum D.O. must be above 5.5 to be minimally suitable to trout ($SI \geq 0.3$) with optimal conditions ($SI=1$) > 9.0 mg/L. Thus, trout habitat suitability decreases but is marginally suitable as D.O. decreases from > 9.0 to 5.5 and habitat becomes unsuitable as D.O. decreases below 5.5 mg/L.

Dissolved oxygen is also important for cold water adapted stoneflies and other cold water macroinvertebrates. Most of these species have adapted simple gill structures and primitive behavioral adaptations (e.g., “pushups”) to obtain oxygen because they have evolved in streams with relatively high oxygen saturation (Eriksen et al., 1996). Similar to trout, dissolved oxygen levels below 5 mg/l are likely to be unsuitable to many of these cool water invertebrate species, especially as water temperature increases (Eriksen et al., 1996).

Physical habitat

Optimal physical habitat for trout is characterized by clear, cold water; a silt-free rocky substrate in riffle-run areas; an approximately 1:1 pool-to-riffle ratio, with areas of slow, deep water; well-vegetated stream banks; abundant instream cover; and relatively stable water flow, and stable stream banks (Calhoun, 1966; McAfee, 1966; Raleigh and Duff, 1980). Similarly, cold water adapted stream invertebrates generally prefer cool water temperatures year-round, cobble or gravel substrate, which is well aerated, moderate current velocity, stable riparian banks, and adequate shading (Usinger, 1968; Ward and Stanford, 1982; Minshall, 1984).

For trout habitat, physical habitat factors are divided into three types of variables: pool depth and current velocity; substrate size, and riparian condition. Pool/depth/velocity are related primarily to the adult and juvenile life stages with respect to food availability and predator/prey relationships. The thalweg depth, number of pools, and pool class all influence the suitability of resting and feeding areas. The substrate size variables are primarily related to the embryo and fry life stages because the substrate needs to be suitable for spawning and needs to provide the proper interstitial space for embryo and fry development. The riparian variables are related to all life stages because riparian vegetation is the source of allochthonous input and it regulates water temperature (% midday shade) and sediment loading (% streamside vegetation erosion). Table 5-2 summarizes physical habitat variables affecting trout habitat suitability and the respective minimum threshold values. Minima apply to all life stages. Ranges reflect differences among life stages.

Table 5-2. Physical factors that determine habitat suitability for rainbow trout (Raleigh et al., 1984).

Component	Variable	Minimal Habitat (SI ≥ 0.3)
A	Average thalweg depth	> 26 cm
A, J	% instream cover	> 2
A, J. F	% pools	0 – 100%
A, J	Pool class rating	A, B, or C
F	% substrate size class	> 3%
F, O	% riffle fines	< 45%
E	% riffle fines	< 18%
E	Average water velocity	16-83 cm/s
E	Average gravel size in spawning areas	0.,5-8.5 cw
O	% streamside vegetation	> 50
O	% midday shade	0-100%
O	% streamside vegetation (erosion)	> 25%

The following summarizes several key physical habitat parameters that were evaluated to assess COLD use attainment:

Sediment Particle Size. Pennak and Van Gerpen (1947) reported that the production of benthic invertebrates is greatest in cobble (rubble), followed by bedrock, gravel, and finally sand. Most macroinvertebrates are somewhat specific in terms of their substrate requirements as they live nearly all of their life cycle in the benthic sediment. Cold water stoneflies in North America have generally adapted to living in streams with mineral particle sizes (gravels, cobbles) and/or leaf packs or other coarse particulate matter (Stewart and Stark, 1988), probably because most naturally cool waterbodies are either in montane regions (where particle sizes are generally not sand or silt) or in heavily shaded areas (where detritus is plentiful). Several researchers have demonstrated a general preference of cool water macroinvertebrate species for particle sizes larger than sand, in which there are abundant interstitial spaces and/or particulate organic material available (Hynes, 1976; Reice, 1980; Minshall, 1984).

Trout also require a variety of sediment particle sizes during their life cycle, and particularly prefer gravel-cobble sediment, free of silt and other fine particles (Raleigh et al., 1984). Trout spawning and rearing requires well-aerated sediments that will maintain egg viability and also attract macroinvertebrates and other prey items. The presence of fines in riffle-run areas can adversely affect embryo survival, food production, and escape cover for juveniles as well as feeding opportunities for cold water invertebrates (Chapman and Knudson, 1980; Merritt and Cummins, 1996; Osborne and Kovacic, 1993). It is well known that aquatic invertebrates, which make up a large part of the trout diet, are most abundant and diverse in riffle areas with gravel-cobble substrate, and on submerged aquatic vegetation (Hynes, 1970; Barbour et al., 1999).

Riparian Conditions. Canopy cover is important in maintaining shade for stream temperature control and in providing allochthonous food to many cold water macroinvertebrates in small to moderate size streams, (Hynes, 1970; Vannote et al., 1980; Stewart and Stark, 1988; Merritt and Cummins, 1996). About 50% to 75% midday shade is optimal for trout (Raleigh et al., 1984) and most cold water invertebrates in most small streams (Hynes, 1970b), particularly those that receive strong sun radiation such as those in the Central Valley. In addition, a well-vegetated riparian area helps control sedimentation to the stream (Cooper et al., 1987; Steedman, 1988; Allan and Johnson, 1997; Diamond et al., 2002; Wang and Lyons, 2003). In low to moderate gradient terrain, such as the Central Valley, a buffer strip about 30 m wide on each side of the stream, 80% of which is either well vegetated or has stable rocky stream banks, provides adequate erosion control and maintains undercut stream banks characteristic of good salmonid habitat (Raleigh et al., 1986).

The conceptual model presented in Figure 5-2, includes factors that address riparian habitat quality suitable to Rainbow/Steelhead trout and macroinvertebrates. These include percent streamside vegetation, bank vegetation, canopy, percent midday shade, as well as bank vegetative composition (derived from the individual percentages of trees, shrubs, and grasses/forbes).

Pool/Cover Quality. Pool/cover quality is a natural physical condition that affects all salmonids and is recognized as one of the essential components of salmonid streams. Cover for adult trout consists of areas of obscured stream bottom in water ∃ 15 cm deep with a velocity of # 15 cm/sec (Wesche, 1980). Cover is provided by overhanging vegetation, submerged vegetation, undercut banks, instream objects (such as debris piles, logs, and large rocks), pool depth, and surface turbulence (Giger, 1973). Pool quality is dictated by the percentage and proportion of pools and the overall pool cover. Total percent cover, and winter cover specifically, influence overall fish cover quality. Winter cover is described as areas consisting of quiet backwaters and deep (∃ 45 cm) pools with dense cover of roots, logs, debris jams, flooded brush, or deeply undercut banks during winter.

The conceptual model (Figure 5-2) includes several parameters indicative of overall pool and cover quality including pool depth, percentage and proportion of pools in the stream, and pool class (a qualitative ranking based on trout preferences).

Current Velocity. Current velocity is a critical habitat component for both stream-dwelling trout and cold water macroinvertebrates. Trout rely on the stream current to bring prey items, such as aquatic invertebrates to its feeding territory as these fish typically use an "ambush" feeding strategy (Behnke, 1992; Raleigh et al., 1984). In addition, both stream dwelling trout and cold water macroinvertebrates are adapted to higher dissolved oxygen levels (i.e., the gill structures are less efficient in extracting oxygen than are many warm water adapted species) and therefore need some current velocity to maintain adequate oxygen exchange (Eriksen et al., 1996).

The conceptual model (Figure 5-2) relies on average current velocity, as this is indicative of year-round velocity in the stream.

5.2.2 Data Collection and Results

Two physical habitat investigations were performed in August 2002 and January 2003 to evaluate both warm (dry) and cold (wet) season habitat conditions (see Chapter 4 and Appendix

A for methods). Physical habitat parameters including substrate size and type, velocity, canopy cover, and riparian zone were measured. Water quality parameters examined included temperature and dissolved oxygen data collected by RBI (2002a,b).

The site assessments yielded the following information concerning physical habitat.

Sediment Particle Size. The substrate of Old Alamo Creek is dominated by the natural sand and silts common in soils of the Central Valley (see Table 4-3, Chapter 4). This sediment is a natural result of the geology of the Central Valley ecoregion as well as the relatively low gradient of most valley floor streams that are largely depositional rather than erosional (Schoenherr, 1992; Harden, 1998). SI scores related to sediment particle size indicated that the predominant substrate type is silt and sand in all three segments of Old Alamo Creek, which is unsuitable (SI = 0.3). The habitat SI = 0 for all other sediment particle size variables including percent substrate size class, average gravel size in spawning areas, and percent riffle fines indicate that the substrate present is unsuitable (Table 5-3).

As the substrate of Old Alamo Creek is dominated by sand, aquatic invertebrate production is expected to be low further limiting attainability of fish such as rainbow trout, because of limited prey. Data from other sand-dominated valley floor streams, similar in size to Old Alamo Creek, confirm that these systems support a relatively limited benthic invertebrate fauna as compared to upland streams in the valley (CDFG, 1997, 1998, 2000; Domagalski et al., 2000). The lack of cold water stoneflies in these streams (as well as most mayflies and stoneflies found in higher elevations), is also related, in part, to the unsuitable sediment particle size for growth and feeding (Reice, 1980; Resh and Rosenberg, 1984). As shown in Table 4-3, sediment particle size at this site was very small and, in many locations, consisted of only fine material. This is not conducive to stonefly survival or growth in general (Minshall, 1984). The relatively low stream gradient results in few if any riffle areas that are generally preferred by these and other cold water stream macroinvertebrates.

Riparian Conditions. The stream channel and riparian zone below the “headwaters” of Old Alamo Creek have retained their natural structure however the stream channel is dry for most of the year (see Appendix A). SI scores for trout riparian conditions were > 0.75 for all the riparian-based variables, indicating good to optimal riparian conditions (Table 5-3). The natural riparian cover there is suitable for cold water invertebrates.

Sampling sites downstream of the EWWTP discharge have greater overall cover and a dense riparian canopy. SI scores for sites in this region of Old Alamo Creek indicated that riparian conditions are satisfactory (SI ≥ 0.6) for trout habitat requirements (Table 5-3). Riparian conditions were also suitable for cold water invertebrates in this section of Old Alamo Creek.

Within a short distance downstream of the discharge, the stream has been channelized and the riparian corridor is intensively managed, removing any of the habitat components present in the upper portions of the channel. The lack of channel sinuosity, riparian vegetation, and cover resulted in the lowest habitat scores in the Creek (see Appendix B; Table 4-4) and SI scores that were much more unsuitable than the two segments upstream. Riparian vegetation although present was in the form of grasses and some bushes (SI = 0.58), which doesn’t provide as much cover or allochthonous input as riparian conditions upstream. The lack of midday shade (SI = 0.3) is unsuitable for trout rearing and growth in the spring and summer given the low stream elevation and high prevailing air temperatures (Table 5-3). This segment of Old Alamo Creek has poor riparian cover for macroinvertebrates as well, providing a poor food source and susceptibility to predation.

Table 5-3. Summary of habitat suitability analysis results for rainbow trout in three segments of Old Alamo Creek: (1) upstream of the EWWTP discharge, (2) directly downstream of the discharge but still natural channel, and (3) the downstream, channelized segment to the confluence with New Alamo Creek. Suitability indices marked with the superscript "A" indicate parameters for which relevant seasonal data were unavailable and suitability was assumed to be = 1.0 (optimal). Suitability indices in bold for Old Alamo Creek indicate unsuitable conditions (i.e., does not meet minimum threshold values).

			Old Alamo Creek Suitability Indices		
Rainbow Trout	Minimal Habitat	Optimal Habitat	Above EWWTP	Below EWWTP	Lower OAC
Adult Component	(SI>0.3)	(SI=1.0)	(OA1 - OA5)	(OA6 - OA9)	(OA10 - OA11)
Average Thalweg Depth	>26 cm	>45 cm	0 - 1	1	1
% Instream Cover	>2	>24	1	1	1
% Pools	0 - 100%	35 - 65%	0.5 - 0.8	0.4 - 1.0	**0.3**
Pool Class Rating	A,B,or C	A	**0.3**	0.6	**0.3**
Juvenile Component					
% Instream Cover	>1	>14	1	1	1
% Pools	0 - 100%	35 - 65%	0.5 - 0.8	0.4 - 1.0	**0.3**
Pool Class Rating	A,B,or C	A	**0.3**	0.6	**0.3**
Fry Component					
% Substrate Size Class	>3%	>10%	**0**	**0**	**0**
% Pools	0 - 100%	35 - 65%	0.5 - 0.8	0.4 - 1.0	**0.3**
% Riffle Fines	<45%	<10%	**0**	**0**	**0**
Embryo Component					
Average Max. Temperature	3 - 17 C	7 - 12 C	**0**	**0**	**0**
Average Min. D.O.	>5.5	>9.0	**0**	**0**	**0**
Average Water Velocity	16 - 83 cm/sec	30 - 70 cm/sec	**0**	0.9 - 1[A]	0.4 - 0.6
Average Gravel Size in Spawning Areas	0.5 - 8.5 cm	1.5 - 6 cm	**0**	**0**	**0**
% Riffle Fines	<18%	<4%	**0**	**0**	**0**
Other Component					
Max. Temperature	2 - 23 C	12 - 18 C	**0**	**0**	**0**
Average Min. D.O.	>5.5	>9.0	**0**	**0**	**0**
pH	5.5 - 9.0	6.5 - 8.0	1[A]	1[A]	1[A]
Average Base Flow	>15%	>50%	1[A]	1[A]	1[A]
Predominant Substrate Type	A,B,or C	A	**0.3**	**0.3**	**0.3**
% Streamside Vegetation	>50	>150	0.75 - 1.0	0.6 - 1.0	0.58
% Riffle Fines	<45%	<10%	**0**	**0**	**0**
% Streamside Vegetation (Erosion)	>25%	>75%	1[A]	1[A]	1[A]
% Midday Shade	0 - 100%	50 - 75%	0.8 - 1	0.75 - 0.95	**0**

Pool/Cover Quality. Winter cover was not quantitatively assessed, however, visual assessment of the stream in winter (January) indicated little or no logs, debris jams, or other evidence of appropriate cover for salmonids or cold water invertebrates. Pool quality was satisfactory in the unchannelized portion near the EWWTP discharge but otherwise poor in terms of macroinvertebrate habitat. The poorer habitat conditions in the larger, channelized part of Old Alamo, as well as upstream of EWWTP, would limit cold water macroinvertebrate survival in the stream as well.

Current Velocity. Average current velocities for each sampling location are summarized in Table 4-2, Chapter 4. The sites upstream of the EWWTP discharge have limited flow and very low current velocity resulting in SI scores that indicated unsuitable habitat (Table 5-3). Upstream velocity is not conducive to salmonid rearing and growth (Delisle and Eliason, 1961; Hooper, 1973; McAfee, 1966) or cold water invertebrates such as many cold water stoneflies (Stewart and Stark, 1988; Resh and Rosenberg, 1984). Average velocities downstream of the EWWTP discharge ranged between 14.9 (August) and 87.8 cm/s (Winter). This water velocity range is adequate for cold water species survival and growth.

Temperature. The temperature regime in Old Alamo Creek is not conducive to trout survival, growth, or reproduction. The upper and lower incipient lethal temperatures for adult rainbow trout are 25º and 0º C, respectively (Black, 1953; Lagler, 1956; Mcafee, 1966; Bidgood and Berst, 1969; Hokanson et al. 1977). Zero growth rates occurred at 23º C for rainbow trout in the laboratory (Hokanson et al., 1977). Adult rainbow trout select temperatures between 12 and 19.3º C (Garside and Tait 1958; Bell 1973; Cherry et al., 1977; McCauley et al., 1977). The optimal temperature range for rainbow trout is considered to be 12º to 18º C (Garside and Tait, 1958; Mantelman, 1958; McAfee, 1966; Bidgood and Berst, 1969; Coutant, 1977; Pauley et al., 1986). The maximum temperature at which trout survival and growth can be minimally sustained is 23° C. While individual trout may be observed in streams where temperatures exceed laboratory-determined thermal tolerances, these observations may not indicate that such streams can support salmonid or other cold water populations (USEPA, 2000). As shown in Figure 4-2, average and maximum temperatures generally exceed even minimal threshold levels for trout during most life stages (Table 5-3). It has been suggested by Bennett (1987, cited in Nielsen et al., 1994) that high summer temperatures limit the range of all salmonids in California.

The temperature regime is also unsuitable for cold water stoneflies and other cool water macroinvertebrates. Many of these species can not tolerate prolonged time periods (days-weeks) when water temperature is > 15° C (Eriksen et al., 1996; Sweeney, 1984). As demonstrated in Figure 4-2, stream temperature was > 16° C during the spring, summer, and fall, when these species are most susceptible to heat stress.

Dissolved oxygen. While dissolved oxygen concentrations were generally tolerable for cold water aquatic life in Old Alamo Creek, minimum oxygen levels recorded are probably too low (Figure 4-3). The minimum dissolved oxygen measured during critical life stages (especially the embryo – larval life stage) may limit the overall suitability for trout and cold water invertebrates in Old Alamo Creek (Table 5-3).

5.2.3 Decision Tree Analysis

Figure 5-3 summarizes the decision process for evaluating whether COLD use is attainable in this stream. This decision process makes use of information compiled in Step 2 for both cold water stoneflies and salmonids and, where possible, compares results to peer-reviewed minimum threshold levels or criteria for each factor.

Rainbow trout HSI scores for all 11 sites sampled in Old Alamo Creek were 0.0 (see Appendix C), indicating unsuitable habitat for trout in this stream. Habitat and temperature required for the “other” component of the trout HSI indicate limitations with respect to several parameters (Table 5-3) resulting in poor habitat suitability overall for this species.

Results of all HSI analyses indicated that the adult and juvenile components are limited in the segment of Old Alamo Creek above the EWWTP by pool class rating and the lack of water there (Table 5-3). The segment below EWWTP (OA6-OA9) is minimally suitable in terms of the adult or juvenile components but not early life stages. The lower segment of Old Alamo Creek (OA10-OA11) is limited by percent pools and pool class rating due to stream channelization, as well as temperature, substrate size, shade, and percent riffles. Early life stages (fry, embryo) are limited by most habitat parameters important to their survival (Table 5-3) at all sites in Old Alamo Creek.

Obligate cold water macroinvertebrate use of Old Alamo Creek is also unlikely due to several limiting physical constraints including small sediment size, lack of riffles and detrital food material in most of the stream, warm temperatures, and poor pool cover or quality (Figure 5-3).

5.3 Step 3: What factors preclude the attainment of the beneficial use?

Results of analyses compiled for COLD use were applied to the conceptual model presented in Figure 5-2 to determine the degree to which a given factor may be limiting. The more a factor does not meet minimum thresholds, the more limiting it is in precluding attainment of the beneficial use.

Given all of the factors evaluated in this UAA, COLD use does not exist in Old Alamo Creek due to physical factors and hydrologic modification. Physical factors limiting COLD attainability include lack of riffle areas, and poor instream cover. Hydrologic modifications include channelization of the lower portion of Old Alamo Creek (and concurrent lack of cover and bank destabilization) and hydrologic barriers to aquatic life movement at both the upper and lower ends of the creek. Old Alamo Creek clearly does not meet minimum suitable habitat thresholds for sediment size for most if not all salmonid life stages and cold water macroinvertebrates. Furthermore, the lack of suitable trout spawning and rearing areas throughout this stream would further constrain use of this stream by cold water fishes such as trout.

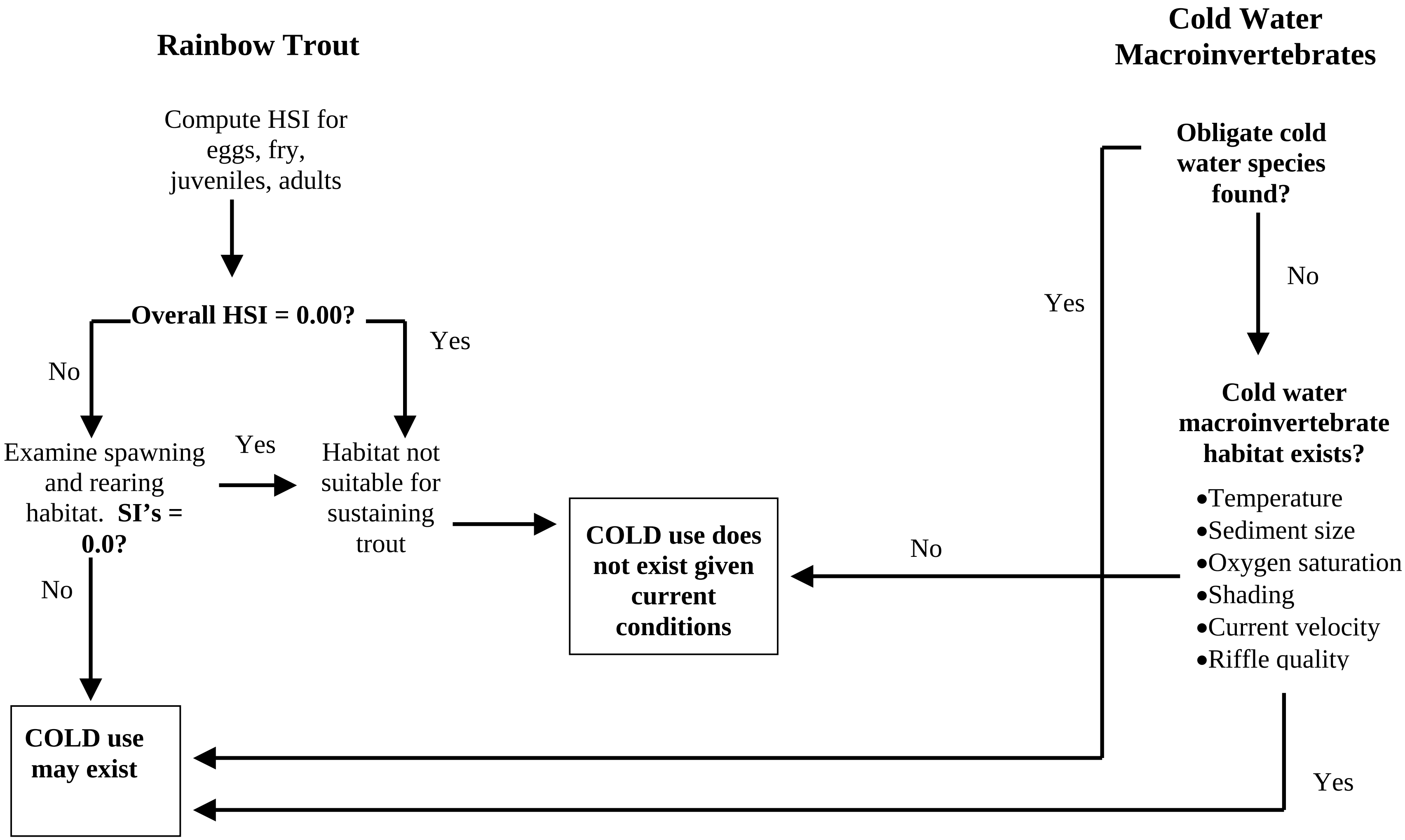


Figure 5-3. Decision tree illustrating factors considered to determine whether water quality and other conditions support the existence of COLD use.

While the existing temperature regime is a factor affecting COLD use in this stream, the results of all analyses indicate that it is not the limiting factor because for brief periods in the winter, temperature is below the tolerable maximum limit for adult trout (Figure 4-2). Furthermore, temperature itself is determined by other factors such as low elevation and the disconnection of Old Alamo Creek with its upper watershed. As there is no connection upstream with surface water flows originating from higher elevations (and therefore cooler sources), stream water temperature is dependent on the temperature (and amount) of groundwater recharge to the stream and the temperature of major surface flows, including the EWWTP discharge and lateral agricultural drains. As indicated in Chapter 2 of this report, surface flows comprise the majority of the dry weather flow to Old Alamo Creek, which is not influenced by naturally cooler groundwater or upstream sources. Thus, temperature is secondary to physical factors and hydrologic modification as a factor limiting COLD attainability.

Available information indicates that obligate cold water invertebrates or fish have not been recorded in several other streams at the same elevation level in the Central Valley, even many that are still connected to their upper watershed and presumably cooler water sources (Brown and Moyle, 1993; Domagalski et al., 2000; Brown and May, 2000b; CDFG, 2000; Brown, 2000). Discussions with Dr. P. Moyle (UC Davis) also indicated that salmonids and other cold water fish do not survive in low elevation streams of the Central Valley. These results further support the interpretation that, given its elevation, physical habitat characteristics, and hydrology, COLD use does not exist in Old Alamo Creek.

Available information indicates that cold water species require lower temperatures and higher dissolved oxygen levels than warm water adapted species. While an extensive literature search was not conducted, information compiled in this UAA suggests that a dissolved oxygen concentration ≥ 5.0 mg/L year-round, and water temperatures >15° C during the spring, summer, and fall, should be satisfactory for supporting warm water aquatic life uses (Figures 5-4 and 5-5, respectively). In contrast, cold water aquatic life, such as trout and cold water stoneflies, may require a dissolved oxygen concentration ≥ 7.0 mg/L much of the year (Figure 5-4) and water temperature <20° C (Figure 5-5). As noted in Section 5.2.2, many studies have demonstrated that rainbow trout prefer temperature between 12 and 18° C. During the spring and summer recruitment period, temperatures between 7 and 12° C are preferred (see Embryo Component, Table 5-3). Available ambient water temperature data reported in STORET and NWIS from other small valley floor streams in the Central Valley (elevation < 200 feet) indicates that temperatures ≥ 18° C are very common in the spring, summer, and fall (April – October) while temperatures <15° C are infrequent. Thus, even under natural conditions (i.e., no wastewater effluent present), it is doubtful that Old Alamo Creek would have a temperature regime conducive to attaining a COLD use. This information further supports the indication that temperature and dissolved oxygen regimes in Old Alamo Creek would not support the existence of COLD use due to natural physical factors.

Weight-of-evidence, based on the factors in the conceptual model (Figure 5-2), indicates that channel modification, elevation, and both natural and human-made hydrological factors limit COLD use attainment in Old Alamo Creek.

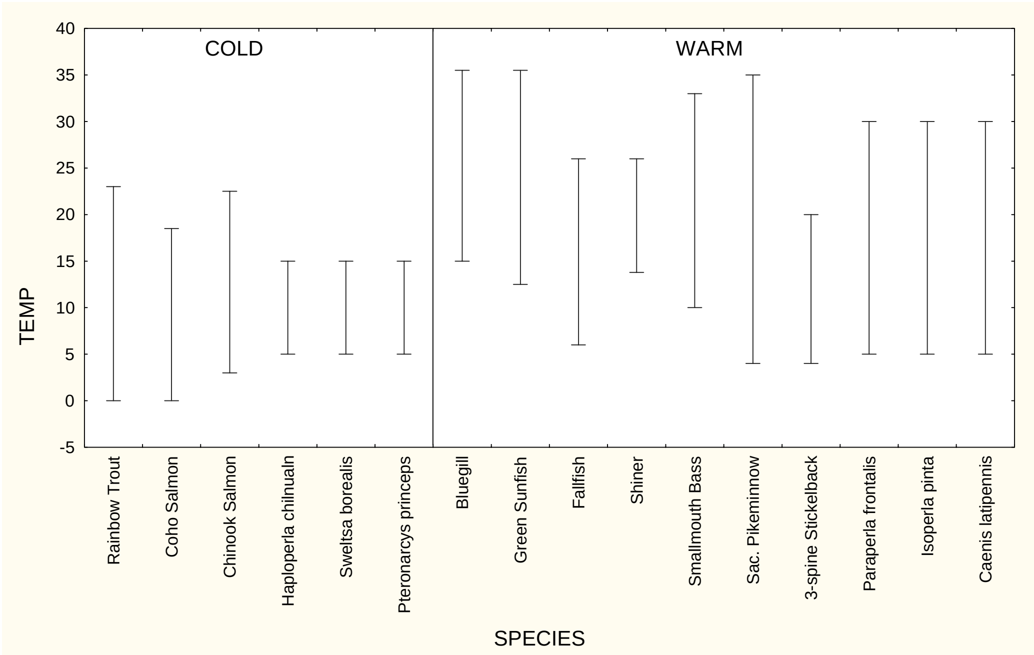


Figure 5-4. The relative difference in temperature requirements between cold and warm water species.

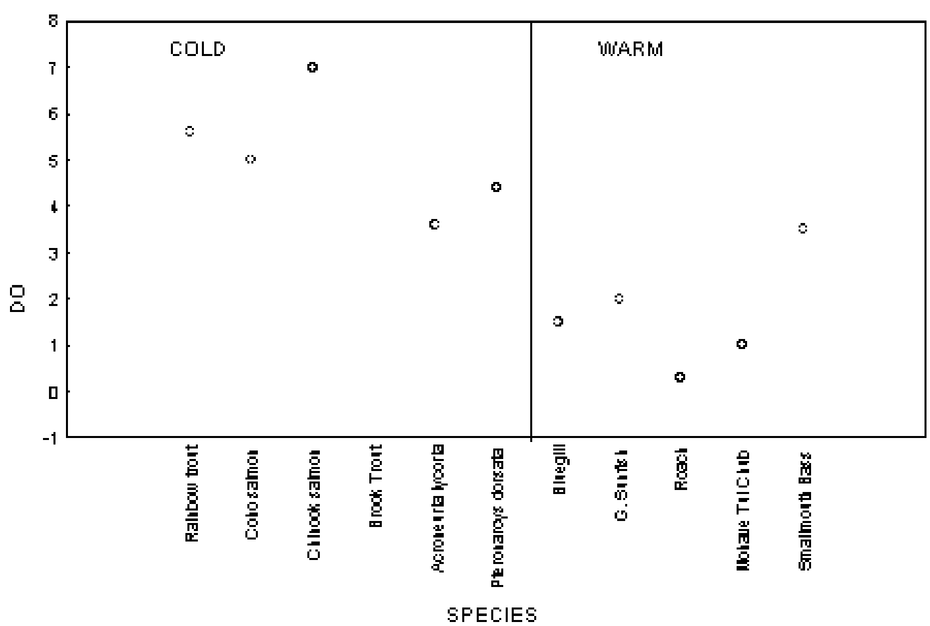


Figure 5-5. Minimum satisfactory dissolved oxygen (DO) concentrations (mg/L) for representative warm and cold water species.

5.4 Step 4: Is restoration feasible?

Given the stream elevation and hydrological modifications present, temperature is too high to sustain cold water biota in Old Alamo Creek. Based on a literature review and discussions with state, federal, and academic biologists, Old Alamo Creek is unlikely to support COLD beneficial uses without extensive physical habitat modifications and perhaps major land use changes in the surrounding watershed.

Hydrological modifications, including channelization of much of the stream and disconnection with its upper watershed, result in few riffle areas, relatively poor habitat cover, poor riparian habitat, and lack of water-cooling potential. Stream channelization and riparian habitat could be addressed by creating a more meandering channel, along with more extensive riparian vegetation planting, similar to what is observed near the EWWTP discharge. However, this would not address the need for riffle areas. The lack of riffles and resulting small sediment size in this stream (sands and silts) is a natural phenomenon resulting from the low stream gradient, its position near the valley floor, and natural surrounding geology. Riffles could be created via artificial low-head dams placed in strategic locations downstream of the EWWTP discharge, where there is sufficient flow to maintain riffle areas but, apart from transporting in larger size sediments such as gravels and cobbles, the sediment size constraint is probably not restorable. While engineering and cost feasibility of these modifications has not been evaluated, it is likely that COLD use may still not be attainable in Old Alamo Creek given its elevation and prevailing air temperatures, and its disconnection with the upper watershed.

Basis for Removal of Designated Use

The CWA factors for allowing a State to remove a designated use are listed in 131.10(g). Several 131.10(g) factors preclude attainability of COLD use in Old Alamo Creek (see Figure 5-3) as described below.

For removal of COLD for Old Alamo Creek, it has been demonstrated that attaining the designated use is not feasible because of factor 131.10(g)(4): "*Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use*." Due to the fact that Old Alamo Creek has been cut off from its upper watershed, there are no current sources of cooler water to the Creek resulting in higher water temperatures year-round, when combined with the low elevation and the region in which it is located. Furthermore, hydrologic modifications on both the upstream and downstream ends of this Creek constitute impassable barriers (iron flapper gates downstream and no channel upstream). Thus, the stream has little or no means of recruiting cold water populations from either upstream or downstream.

In addition, COLD use is not attainable because factor 131.10(g)(5) is present: "*Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unless these conditions may be compensated, unrelated to water quality preclude attainment of aquatic life protection uses.*"

Several natural features of Old Alamo Creek are not conducive to cold water aquatic life including substrate size, pool depth, riffle quality, and temperature. The latter parameter is a consequence of both the low elevation and warm region in which the Creek is located as well as hydrologic modifications as noted above, which prevent cooler water from reaching this Creek.

In this case, COLD is not a 101(a) use and is a result of State policy applying beneficial uses to tributaries. Old Alamo Creek has not demonstrated COLD use qualities nor has there been any societal demands to use Old Alamo Creek in this way. Therefore, it is not necessary to evaluate potential widespread economic and social impacts of potential remedies that may be technically feasible (but impractical) because an investment in restoration technology would be inappropriate if the waterbody is not intended to be used for COLD water aquatic life habitat.

Therefore, as a result of a combination of factors described in 40 CFR 131.10(g)(4), and (5) of the Federal water quality standards regulation, the COLD designation of Old Alamo Creek does not apply for purposes of interpreting the tributary policy of the Regional Board.

6. Evaluation of Attainability for Migration of Aquatic Organisms

The Migration of Aquatic Organisms (MIGR) beneficial use specifies conditions suitable to support habitats necessary for migration or other temporary activities by anadromous or catadromous aquatic organisms.

6.1 Step 1: Is the designated use being attained?

6.1.1 Background

The presence of migratory species, or any records of migratory species being present since November 28, 1975, would demonstrate that the MIGR use exists. The major cold water species that could potentially migrate upstream from this region of the Central Valley are steelhead trout and chinook salmon (Yoshiyama et al., 1998). Warm water anadromous species identified in the Basin Plan include striped bass, sturgeon, and shad.

6.1.2 Information Collected

Several discussions were held with fisheries experts in the region to determine whether migrating fish have been reported in Old Alamo Creek since November, 1975 and whether migrating fish could enter Old Alamo Creek from New Alamo Creek downstream. These discussions were also used to identify the historic migration routes in the region for the species of interest. Discussions were held with:

- National Marine Fisheries Service (NMFS)
- California Department of Fish and Game (CDFG)
- RWQCB staff
- Dr. Peter Moyle (U.C. Davis)

In addition, several published sources, specific to the Central Valley, were consulted to further identify reported fish migrating routes. These included:

American shad have been found in the San Joaquin River (Wang, 1986), but the lower reaches of the San Joaquin have not been used extensively for spawning (Hutton, 1980) because of poor water quality, sluggish flow, and reverse flow of the river. The Delta, especially the San Joaquin River between the Antioch Bridge and the mouth of Middle River, and other channels in this area, are important spawning grounds for striped bass (www.delta.dft.ca.gov/stripedbass/biology.asp). Green and white sturgeon have been reported in the San Joaquin River (Radfke, 1966; Stevens and Miller, 1970; Miller, 1972).

6.1.3 Results

In order for migratory fish to enter Old Alamo Creek, they must enter Cache Slough from the Sacramento River, swim upstream into Ulatis Creek, and then on upstream into Alamo Creek (see Chapter 2). Cache Creek has been known to have migrating steelhead trout and occasionally salmon since 1975 (NMFS, personal communication). No records of migrating fish in Old Alamo Creek were identified although there was an undocumented report of steelhead trout in New Alamo Creek, according to NMFS personnel.

6.2 Step 2: Is water quality sufficient to attaining the beneficial use?

6.2.1 Background

Two indicators are used that encompass the requirements for attainability of a fish migratory use: (1) the fish need to have access to, and through, the segment during migration season, and (2) the habitat must be conducive to migration. Implicit in the first indicator is whether fish can migrate via the segment to an area that supports either spawning, rearing, or adult feeding activities. Indicator measures examined for this use are evaluated in the context of the migratory fish species referred to in the Basin Plan (see Conceptual Model, Figure 6-1).

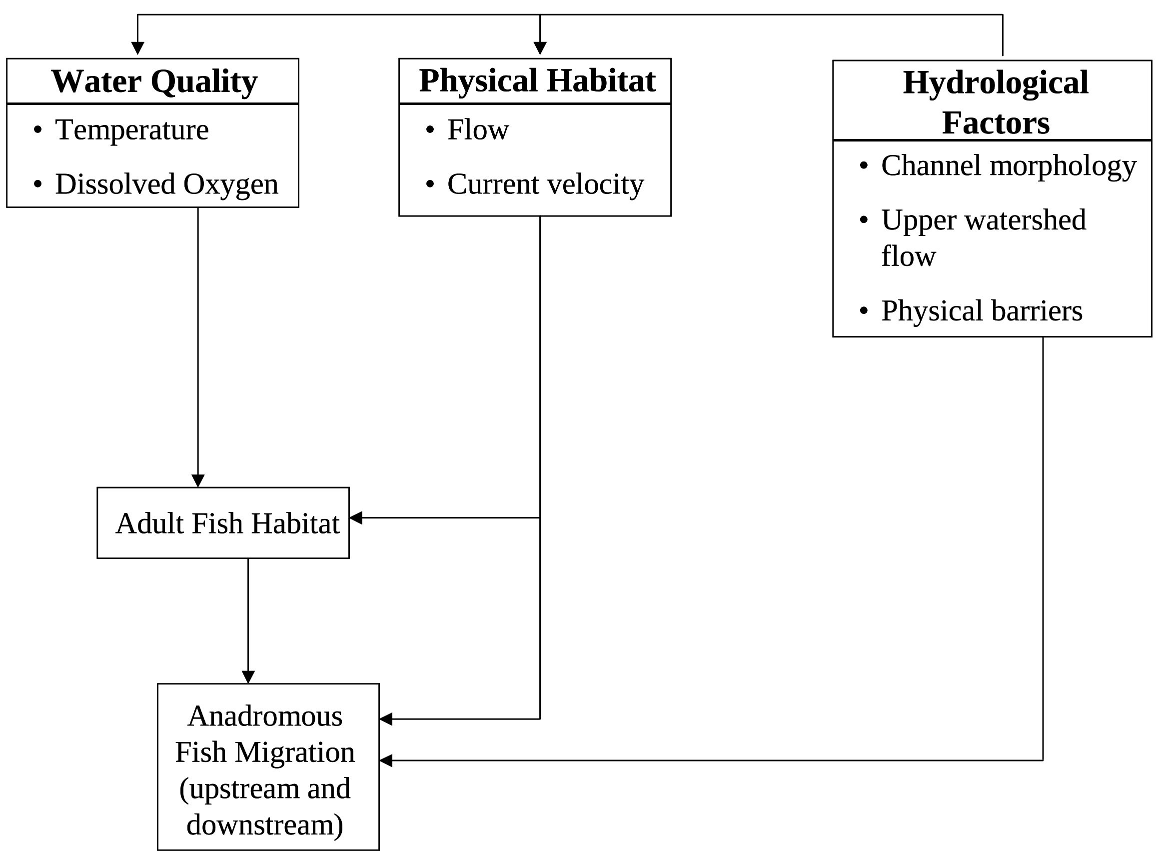


Figure 6-1. Simplified conceptual model illustrating key factors affecting anadromous fish migration (MIGR).

Habitat suitability indices (HSIs) for migratory lifestages of the species of interest were calculated based on habitat information for the respective migration seasons (fall-winter for the cold water species, spring-summer for the striped bass, sturgeon, and shad). These HSIs also addressed whether each of these species could constitute a viable "run" in the sense of eventual spawning and recruitment potential (see SPWN Use in Chapter 4). Chapter 4 discusses the advantages and limitations of HSIs.

Several types of structures may prevent the attainment of MIGR. A stream culvert under a road may be a barrier if it fails to allow passage of a given species at or below a designated stream flow (USFS, 2002). Thus, culverts may or may not be barriers to fish movement but almost always represent suboptimal conditions. Dams block the use of the upper watershed by fish. Access to upper portions of the watershed is particularly important for cold water migrating fish in Central Valley watersheds. Historically, salmonids migrating upstream in the spring spawned and reared during the summer months at higher elevations where water temperature was cooler (Yoshiyama et al., 1998). Structures that block migration at a species preferred time can result in poor survival, increase in disease and infections, and population declines. Structures that are partial barriers may block smaller or weaker fish of a population and limit genetic diversity that is essential for a robust population.

In order for a waterbody to support MIGR, the water quality and physical habitat must have certain characteristics to support passage. The water quality and habitat assessments used to determine MIGR attainability parallel those used to evaluate COLD and SPWN uses. Specific factors include: temperature, flow, sediment particle size, and pool or cover quality.

6.2.2 Data Collected

Two separate site assessments were performed, one in August 2002 and one in January 2003 in which potential barriers were observed, recorded, and evaluated. Discussions with fishery experts from NMFS, CDFG, and Dr. Peter Moyle helped determine whether particular structures were likely to be barriers to fish migration. Habitat, temperature and dissolved oxygen data, described in Chapter 4, were also used in this assessment.

6.2.3 Results

The flow of Alamo Creek was diverted to a constructed channel in the late 1960's, leaving behind an abandoned natural channel that receives little or no input from the upper reaches of Alamo Creek. The stream channel and riparian zone below the "headwaters" of Old Alamo Creek at site OA 1 retain their structure (Figure 2-2), but the stream channel above the EWWTP is dry for much of the year. Flows in this upper portion of Old Alamo are primarily derived from stormwater from adjacent neighborhoods. Thus, even if fish are capable of migrating into Old Alamo Creek, past the flapper gates, the fact that there is no flow above the EWWTP discharge means that migrating fish must spawn in Old Alamo Creek.

Two hydrological modifications, one on the upstream end and one on the downstream end of Old Alamo Creek, are present which are likely to be barriers to fish migration. On the downstream end of the creek, Old Alamo Creek enters New Alamo Creek through a small basin and four iron flapper gates (see Figure 6-2). The MIGR use of Old Alamo Creek is limited to times when excessive rainfall and subsequent stormflow, generates a water level rise that is sufficient to keep the four flapper gates continuously open for some period of time (days for example), thereby creating a direct connection between downstream New Alamo and Old Alamo Creek. Under normal flows, the flapper gates permit a small flow of water to converge with New Alamo Creek, inhibiting either the upstream or downstream passage of fish.

Figure 6-2. Confluence of Old Alamo Creek with New Alamo Creek through four iron flapper gates.

Results of HSI analyses indicate that Old Alamo Creek does not support conditions suitable for adult salmonids, should they enter the stream (Table 7-1), nor does the stream support conditions to sustain eggs or juveniles of these migratory species (see SPWN use, Chapter 7). HSI analyses conducted for striped bass, sturgeon, and shad indicated suitable spawning habitat conditions for shad and striped bass (Table 7-2), however, the flapper gates would likely prevent migration of these species into Old Alamo Creek.

The decision tree for evaluating whether current conditions can support the MIGR use is presented in Figure 6-3. Results of all analyses indicate that the MIGR use is not attainable given current conditions.

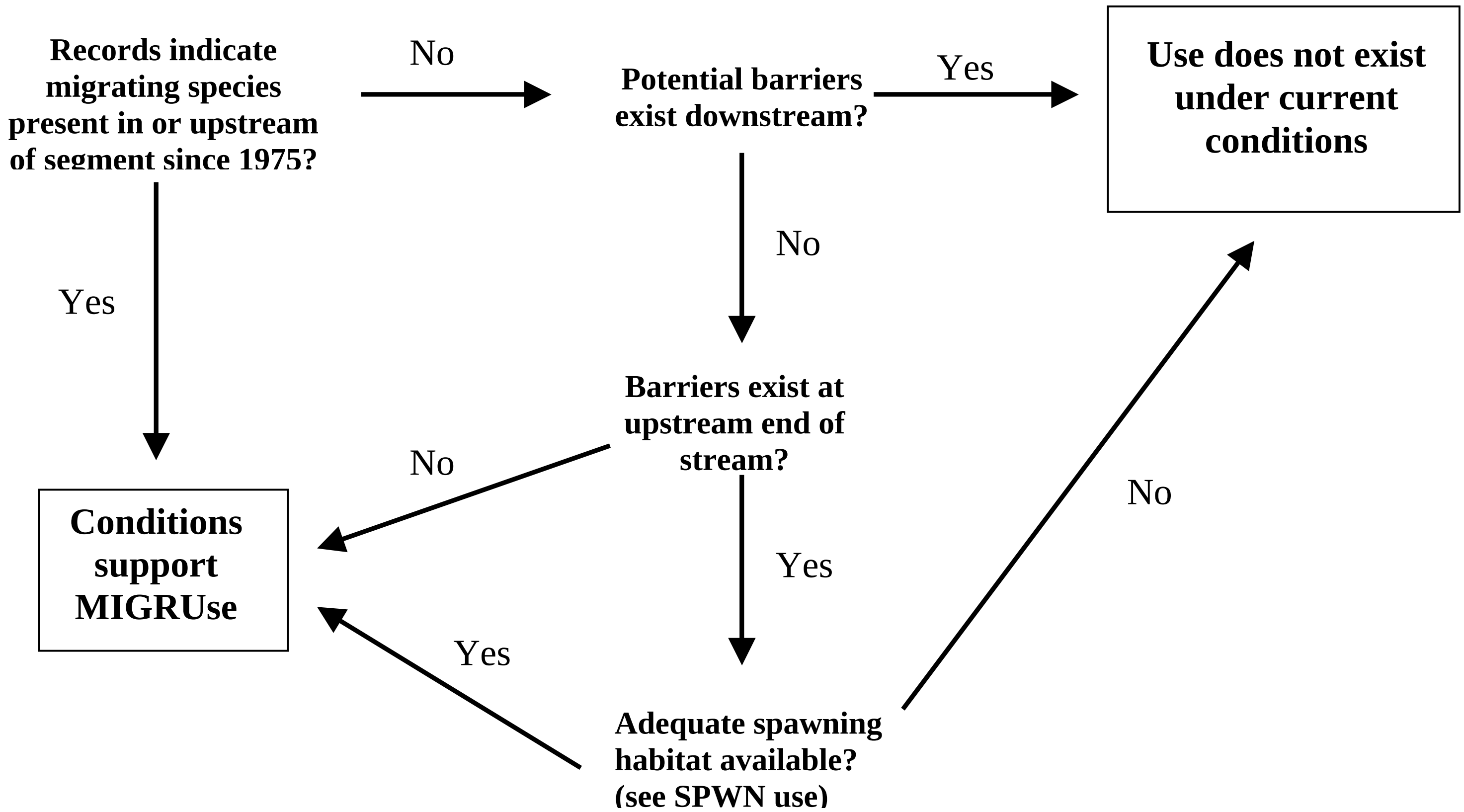


Figure 6-3. Decision tree illustrating factors considered to determine whether water quality and other conditions support the existence of MIGR use.

6.3 Step 3: What factors preclude the attainment of the beneficial use?

Information compiled for this analysis indicates that anadromous salmonids historically migrated from the ocean into the Sacramento River and then on up into several major tributaries in the Central Valley (Yoshiyama et al., 1998). Spring and summer runs historically migrated to cooler water in higher elevation streams in the Sierras or Coast Range where there were more suitable spawning grounds (Yoshiyama et al., 1998). Available information suggests that the relatively larger tributaries in the Central Valley (e.g., Feather, American, Merced) served as major migratory conduits for anadromous fish species because stream flow was suitable and predictable. With the advent of the California Water Project in the Sierras, beginning in 1935, stream flows diminished in many Sacramento River tributaries (including the upper San Joaquin River), resulting in diminished or extirpated fish runs (Sweeney, 1991). Available evidence suggests that smaller Central Valley streams, not connected to higher elevation watersheds, were not historically migratory routes for anadromous fish (P. Moyle, personal communication).

Based on information compiled and evaluated in this UAA, hydrological modifications result in physical barriers that limit the use of Old Alamo Creek as a meaningful migratory waterway for both cold and warm water fishes (see the Conceptual Model Figure 6-1). Both the iron flapper gates at the confluence of Old Alamo Creek with what is now New Alamo Creek, and the diversion of upper Alamo Creek flow from Old Alamo Creek into New Alamo Creek, severely limit the ability of fish to migrate into or out of Old Alamo Creek.

6.4 Step 4: Is restoration feasible?

Two factors limit migration in Old Alamo Creek: flapper gates at the downstream confluence with New Alamo Creek and disconnection with its upper watershed on the upstream end, above the EWWTP discharge.

Removal of Flapper Gates

The fish barrier at the downstream end of Old Alamo Creek consists of a set of iron flapper gates that are designed to stay closed except when flows are high. Removal of this barrier would not appear to compromise the function of the creek in terms of water conveyance. However, flood conditions in New Alamo Creek would result in a back-up of water into Old Alamo Creek and potential flooding of agricultural land surrounding the stream.

Removing the flapper gates, and allowing fish to migrate more easily up into Old Alamo Creek could be a net negative benefit to these fish populations. As discussed in Section 2.3 of this chapter, physical habitat conditions (sediment particle size, riparian conditions, pool/cover quality, and current velocity) are unsuitable for adult maintenance and/or spawning of cold water anadromous fish species. These habitat features are naturally occurring in small valley floor streams of the Central Valley as discussed in Chapter 5, and, therefore, are modified only with sustained efforts. Thus, at least for the salmonids, adult fish that did migrate into Old Alamo Creek are unlikely to survive and reproduce there, negating the intended beneficial use of MIGR. While spawning habitat for shad and sturgeon is theoretically suitable, it is doubtful that a sustained run could be established for either species due to difficulties migrating upstream to spawning areas and downstream to estuarine feeding grounds (Crance, 1986). Creating habitat suitable for spawning of anadromous fish is further discussed in Chapter 7, and was generally determined to be infeasible for most of these species.

Reconnect Old Alamo with its Upper Watershed

Old Alamo and the diversion point (New Alamo) have become developed suburban neighborhoods within Vacaville. The “headwaters” of Old Alamo are now within Nelson Park, which is .28 mile from the diversion point. To reconnect Alamo with Old Alamo would require extensive modification of city streets and neighborhoods that now lie between the two points. In addition, a careful analysis of the flood hazard represented by the reconnected channels would have to be undertaken. New Alamo Creek now carries the flow from the upper watershed and is therefore, more conducive as a viable migratory corridor for fish.

Basis for Removal of Designated Use

The CWA factors for allowing a State to remove a designated use are listed in 131.10(g). Several 131.10(g) factors preclude attainability of MIGR use in Old Alamo Creek (see Figure 6-3) as described below.

For removal of MIGR for Old Alamo Creek, it has been demonstrated that attaining the designated use is not feasible because of factor 131.10(g)(4): "*Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use*." Due to the fact that Old Alamo Creek has been cut off from its upper watershed, there is nowhere for fish to migrate upstream. The upstream diversion also does not allow potentially cooler water from Mt Vaca to reach Old Alamo Creek, resulting in higher water temperatures year-round, when combined with the low elevation and the region in which it is located. This further restricts cold water migratory fish species such as salmon and steelhead. Hydrologic modifications on the downstream end of this Creek in the form of iron flapper gates constitute an impassable barrier to migrating fish species (warm or cold) most if not all of the year. Thus, fish can not readily move upstream into Old Alamo Creek.

In addition, MIGR use is not attainable because factor 131.10(g)(5) is present: "*Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, unless these conditions may be compensated, unrelated to water quality preclude attainment of aquatic life protection uses.*" Several natural features of Old Alamo Creek are not conducive to the survival and rearing of migrating fish species in the region. Specifically, natural features such as substrate size, pool depth, riffle quality, and current velocity are not satisfactory for many migratory species.

Thus, MIGR is not a 101(a) use in Old Alamo Creek and is a result of State policy applying beneficial uses to tributaries. Old Alamo Creek has not demonstrated MIGR use qualities nor has there been any indication that Old Alamo Creek might be effectively used in this way. Therefore, it is not necessary to evaluate potential widespread economic and social impacts of potential remedies that may be technically feasible (but impractical) because an investment in restoration technology would be inappropriate if the waterbody is not intended to be used for migrating fish species.

Therefore, as a result of a combination of factors described in 40 CFR 131.10(g)(4), and (5) of the Federal water quality standards regulation, the MIGR designation of Old Alamo Creek does not apply for purposes of interpreting the tributary policy of the Regional Board.

7. Evaluation of Attainability for Spawning, Reproduction and/or Early Development

The Spawning, Reproduction, and/or Early Development (SPWN) beneficial use specifies conditions suitable for reproduction and early development of anadromous fish.

7.1 Step 1: Is the designated use being attained?

The SPWN use pertains to both warm and cold water anadromous fish species. Therefore, attainability of this use was evaluated on the basis of suitable habitat conditions for the cold or warm water anadromous fish species examined for the migration (MIGR) use (Chapter 6): steelhead trout, chinook salmon, striped bass, sturgeon, and shad. For each species, habitat parameters measured during the spawning season were used to assess the degree to which fish spawning, egg incubation, and early life stages are capable of occurring. All of these life stages are critical to the attainability of this use because they are all indicative of satisfactory spawning potential.

7.1.1 Available Information Prior to UAA

Discussions with fishery biologists from NMFS, CDFG, and Dr. Peter Moyle (U.C. Davis) indicated that there was no evidence of anadromous fish species spawning in Old Alamo Creek since November, 1975. However, many steelhead spawning streams in higher elevations are known to become intermittent periodically due to drought, which may result in elevated juvenile mortality in the summer (Titus et al., 1999). According to NMFS (Rodney McInnis, personal communication), localized extirpations and recolonization of salmon and steelhead are common in the Central Valley and may be facilitated by life history characteristics such as straying and the return of early maturing adults (i.e., “jacks”). American shad spawning grounds are located above Rio Vista on the Sacramento and its major tributaries, as well as on the Feather and American Rivers (Wang, 1986). The major spawning areas for white sturgeon are historically in the Sacramento River between Freeport and Colusa (Kohlhorst, 1976). This species also uses the Feather River as spawning grounds (Moyle, 1976; Kohlhorst, 1976). Important striped bass spawning grounds are the Sacramento River between Sacramento and Princeton (www.delta.dfg.ca.gov/stripedbass/biology.asp).

7.1.2 Field Data Collection

In addition to collecting habitat information for computing habitat suitability indices, fish sampling during both the dry season in August, 2002 and the wet season in January 2003 was performed to assess the presence of either breeding adults, gravid females, or young of the year of anadromous species. The presence of young of the year is indicative of successful spawning.

7.1.3 Field Collection Results

No anadromous fish species were collected in either the August or January surveys (see Table 4-5, Chapter 4). Therefore, there is no direct evidence that the SPWN use currently exists.

7.2 Step 2: Is water quality sufficient to attaining the SPWN beneficial use?

7.2.1 Background

For the SPWN use to exist, several factors related to water quality and physical habitat need to be present during different early life stages for a given species (see the conceptual model, Figure 7-1). These include temperature, dissolved oxygen, sediment size, pool quality (depth, cover, size), and current velocity. Similar to the COLD use (Chapter 5), many of these factors need to be within specified tolerance ranges in order to successfully realize spawning potential.

Three warmwater and two coldwater anadromous fish were analyzed using HSI's to determine if water quality is sufficient to attain the SPWN beneficial use.

Warmwater fish	Coldwater fish
American shad (*Alosa supidissima*)	Chinook salmon (*Oncorhynchus tshawytscha*)
Striped bass (*Morone saxatilis*)	Steelhead trout (*Salmo gairdneri*)
Shortnosed sturgeon (*Acipenser brevirostrum*)*	

*Shortnosed sturgeon was used as a surrogate because a formal HSI is not available for either white or green sturgeon.

The factors that limit spawning as related to relevant lifestage components (egg, larval, juvenile) or reproduction components of the five anadromous fish are discussed below.

<u>Temperature</u> Warm water and cold water anadromous fish have different thermal tolerances and suitability ranges by definition. The timing of the spawning run is highly correlated with water temperature, ensuring that the majority of adults arrive at the spawning grounds when temperature is optimum for egg and larval survival (Leggett and Whitney, 1972; Pekovitch, 1979; Taubert, 1980a; Dadswel et al., 1984). Therefore, temperature can be limiting because of the reliance on temperature to determine time of spawning as well as aiding in the development and hatching of eggs and larvae. Also, oxygen saturation and fish metabolism vary with temperature; as temperature increases the biological demand for oxygen increases, but the available oxygen supply decreases (Raleigh et al., 1986).

<u>Dissolved Oxygen</u> Minimum dissolved oxygen levels are required for proper egg development and hatching as well as juvenile and adult survival. Doudroff and Shumway (1970) reported that salmonids incubated at low dissolved oxygen were weak and small with slower development and increased abnormalities. As mentioned above, dissolved oxygen levels are related to temperature. The dissolved oxygen levels needed for survival of Chinook salmon with short-term exposures is ≥ 2.5 mg/L at water temperatures ≤ 7° C with optimal levels of ≥ 8 mg/L at water temperatures ≥ 7 but ≤ 10° C and 12 mg/L at temperatures > 10° C (Raleigh et al., 1986). Optimal oxygen levels for steelhead trout are not well documented but appear to be ≥ 7 mg/L at temperatures ≤ 15° C and ≥ 9 mg/L at temperatures > 15° C (Raleigh et al., 1984). Warm water fish dissolved oxygen levels are similar to those presented for the cold water fishes. Striped bass eggs and larvae have been reported absent at dissolved oxygen concentrations of 2.5-3.0 mg/L (Muramshi, 1969; Chittenden, 1971). Turner and Farley (1971) reported that even moderate reductions in dissolved oxygen concentrations (from 5 to 4 mg/L) decreased the survival of eggs of this species. Marcy (1976) found no shad eggs at dissolved oxygen levels less than 5.0 mg/L. D.O. levels less than 1.0 mg/L caused total mortality to shad eggs (Carlson, 1968).

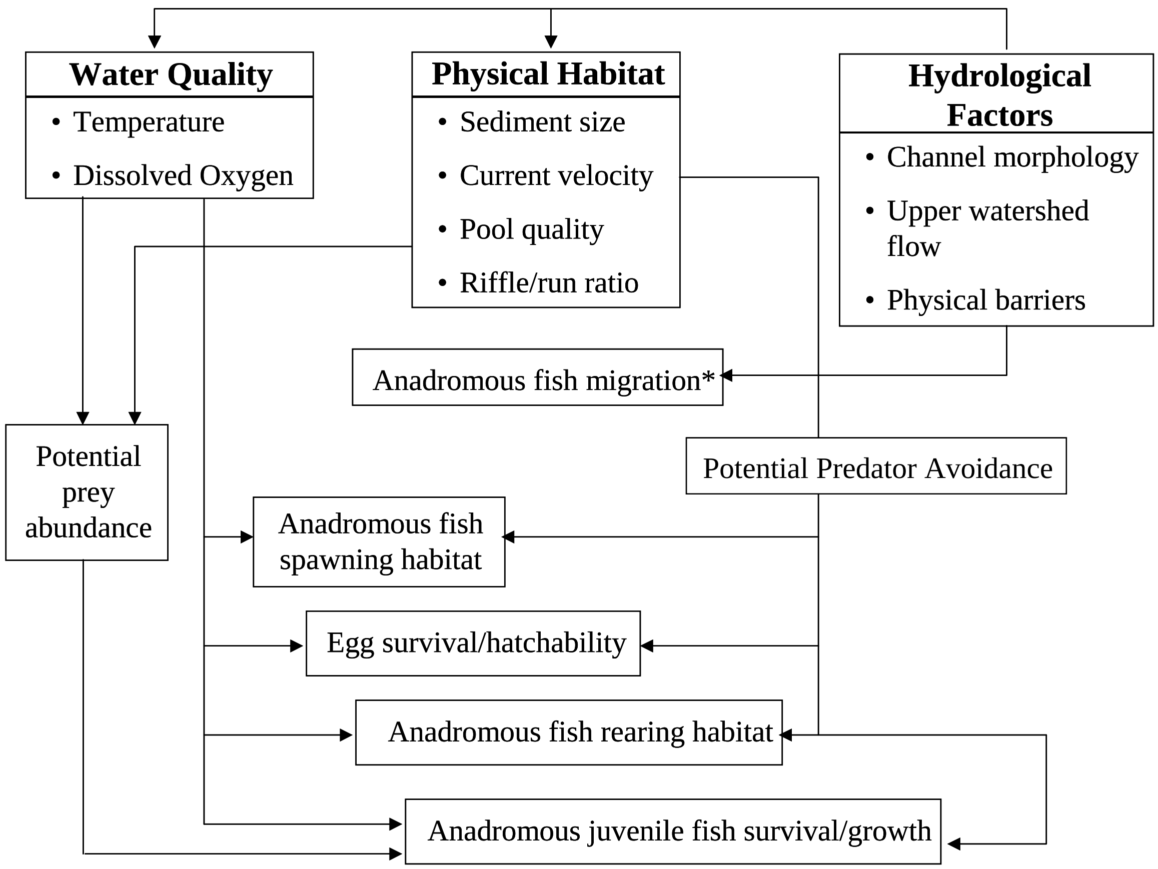


Figure 7-1. Simplified conceptual model showing major factors affecting anadromous fish spawning use.

Substrate Cold and warm water fish require a similar mix of substrate. Suitable incubation substrate for Chinook embryos appears to be gravel that is 0.3 - 15 cm in size and is relatively free of fines (Raleigh, et al., 1986). Optimal gravel conditions for salmonids include ≤ 5% small fines (≤ 0.8 mm) and < 10% large fines (≤ 3.0 mm); amounts greater than these are thought to result in increasingly low survival of embryos and emerging yolk sac fry (Raleigh et al., 1986; Raleigh et al., 1984). American shad have been observed to spawn over a variety of substrates (Mansueti and Kolb, 1953; Walburg, 1960; Leggett, 1976), preferably over sand and gravel bottom with sufficient water velocity to eliminate silt deposits (Walburg and Nichols, 1967). Substrate size influences dissolved oxygen levels in interstitial spaces used by developing eggs and larvae, as well as escape cover, predator avoidance, and food abundance for juveniles.

Pool Quality (depth, cover, and size) The quality of pools is directly related to two factors: prey abundance/predator avoidance and resting areas. Many fish use pools as areas to hunt and to avoid being hunted by avian, terrestrial, and aquatic predators. Platts (1974) found densities of juvenile Chinook associated with large, deep, low-velocity pools. Pools are important to trout as a refuge from adverse conditions during winter. Leveis (1969) found that streams with deep, low velocity pools containing extensive cover had the most stable trout populations. Warm water fish use pools to avoid predators and feed, although the habitat suitability models do not require specific pool qualities for survival.

Current Velocity Current velocity in small streams is related to dissolved oxygen and silt removal from the substrate. The major functions of water velocity during spawning and embryo incubation of salmonids are to: (1) move displaced substrate materials downstream during spawning redd constructions; (2) carry dissolved oxygen to the developing embryos, and (3) remove metabolic wastes from the redd (Raleigh et al., 1986). Trout required certain water velocity over redds of 30-70 cm/sec with velocities less than 10 cm/sec or greater than 90 cm/sec being unsuitable (Delisle and Eliason, 1961; Thompson, 1972; Hopper, 1973). Acceptable spawning and embryo incubation velocities range from 0.2 to 1.15 m/s, with an optimal range of 0.30 to 0.9 m/s, depending on gravel permeability, average substrate size, and average size of spawning adult (Raleigh et al., 1986). Striped bass require certain current velocities to prevent eggs from sinking to the bottom (Talbot, 1966; Bain et al., 1982).

7.2.2 Stream Habitat Data

Tables 7-1 and 7-2 summarize the habitat variables by component for each species listed in Section 2.1 of this chapter.

Anadromous Warmwater

American shad. American shad suitability indices for SPWN in riverine habitat are comprised of two lifestages: adult and egg-larval (Stiar and Crance, 1986). The spawning adult component is comprised of two variables: average water temperature and average current velocity. The egg-larval component is comprised of one variable, average water temperature during incubation. Old Alamo Creek average water temperature was not limiting in any segment for both the adult and the egg-larval component (SI = 1.0). The average current velocity was limiting upstream of the EWWTP, (SI = 0), but downstream of the EWWTP discharge, current velocity was not limiting (SI > 0.8 in both downstream segments).

Striped bass. Striped bass suitability indices are comprised of both riverine and estuarine-based lifestage components. The spawning and egg lifestages are riverine, while the adult, larval, and juvenile stages are estuarine (Bain and Bain, 1982). Therefore, the spawning and egg stages were the only components calculated in this HSI. The spawning component is limited in all three Old Alamo Creek segments by average water temperature (SI = 0.3). The egg component is limited by all three variables: average water temperature (SI = 0.3), minimum dissolved oxygen (SI = 0), and average current velocity (SI = 0.1A). Therefore, striped bass spawning is not likely due to unsuitable water temperature, dissolved oxygen and current velocity.

Sturgeon. The shortnosed sturgeon HSI is composed of two components, food and reproduction (Crance, 1986). Table 7-1 summarizes the variables and their individual SI for the three segments of Old Alamo Creek. The food component was not limiting in any of the segments with all the SI ≥ 0.8. The reproduction component was limited in all three segments by the predominant substrate type (SI = 0.3) and in the upstream site by current velocity (SI = 0).

Table 7-1. Summary of anadromous warm HSI for American shad, striped bass, and shortnosed sturgeon in the three segments of Old Alamo Creek (Raleigh et al., 1984; Raleigh et al., 1986). Suitability indices marked with the superscript "A" indicate parameters for which relevant seasonal data were unavailable and suitability was assumed to be = 1.0 (optimal).

			Old Alamo Creek Suitability Indices		
American Shad	Minimal Habitat (SI>0.3)	Optimal Habitat (SI=1.0)	Above EWWTP (OA1 - OA5)	Below EWWTP (OA6 - OA9)	Lower OAC (OA10 - OA11)
Adult Component					
Average Water Temperature	10 - 24 C	14 - 20 C	1	1	1
Average Current Velocity	0.6 - 3.8 ft/sec	1 - 3 ft/sec	**0**	0.8 - 1	1
Egg-Larval Component					
Average Water Temperature	12 - 28 C	15 - 25 C	1	1	1
Juvenile Component					
Not Calculated (Estuarine)					
Striped Bass					
Adult Component					
Not Calculated (Estuarine)					
Spawning Component					
% Natural River Discharge	>30 %	100%	1^A	1^A	1^A
Maximum TDS	<3.75 ppt	<1.75 ppt	1^A	1^A	1^A
Average Water Temperature	14 - 21.5 C	16.5 - 19 C	**0.3**	**0.3**	**0.3**
Egg Component					
Average Water Temperature	14 - 21.5 C	16.5 - 19 C	**0.3**	**0.3**	**0.3**
Minimum DO	>4.0 mg/L	>5.0 mg/L	**0**	**0**	**0**
Average Current Velocity	>29 cm/s	>30 cm/s	**0**	$0 - 1^A$	**0**
Larval Component					
Not Calculated (Estuarine)					
Juvenile Component					
Not Calculated (Estuarine)					
Shortnose Sturgeon					
Food Component					
Average Water Temperature	9.5 - 30.5 C	10.5 - 22 C	1	1	1
Average Current Velocity	<120 cm/s	16 - 48 cm/s	0.8 - 0.82	1	0.98 - 1
Predominant Substrate Type	1,2,3,4,5,6	1,2,3,4	1	1	1
Reproduction Component					
Average Water Temperature	8 - 17 C	10 - 16 C	0.5	0.5	0.5
Average Current Velocity	15 - 128 cm/s	30 - 76 C	**0**	0.75 - 1	0.99 - 1
Predominant Substrate Type	4,5,6,7,8	5,6	**0.3**	**0.3**	**0.3**

Anadromous Coldwater

Chinook Salmon. The Chinook salmon HSI is limited in all three lifestages: adult, juvenile, and embryo. The adult component is limited by the maximum temperature in all three segments (SI = 0), minimum dissolved oxygen in all three segments (SI = 0.1), and the percentage of pools (SI = 0.2) in the segment above EWWTP and in lower Old Alamo Creek.

Table 7-2. Summary of anadromous cold HSI for Chinook salmon and steelhead trout in the three segments of Old Alamo Creek (Raleigh et al., 1984; Raleigh et al., 1986). Suitability indices marked with the superscript "A" indicate parameters for which relevant seasonal data were unavailable and suitability was assumed to be = 1.0 (optimal).

			Old Alamo Creek Suitability Indices		
Chinook Salmon	Minimal Habitat (SI>0.3)	Optimal Habitat (SI=1.0)	Above EWWTP (OA1 - OA5)	Below EWWTP (OA6 - OA9)	Lower OAC (OA10 - OA11)
Adult Component					
Average Max. or Min. pH	5.7 - 8.6	6.5 - 8	1^A	1^A	1^A
Maximum Temperature	3 - 20 C	8 - 12 C	**0**	**0**	**0**
Minimum D.O.	>6.5	>13	**0.1**	**0.1**	**0.1**
% Pools	10 - 90%	37-67%	**0.2**	0.25 - 0.9	**0.2**
Pool Class	A,B,or C	A	**0.3**	0.3 - 0.6	**0.3**
Juvenile Component					
Average Max. or Min. pH	5.7 - 8.6	6.5 - 8	1^A	1^A	1^A
Maximum Temperature	3 - 20 C	8 - 12 C	**0**	**0**	**0**
Minimum D.O.	>6.5	>13	**0.1**	**0.1**	**0.1**
% Pools	10 - 90%	37-67%	**0.2**	0.25 - 0.9	**0.2**
Pool Class	A,B,or C	A	**0.3**	0.3 - 0.6	**0.3**
Average Base Flow	>20	>50	1^A	1^A	1^A
Average Peak Flow	<5.5 Times	2-3 Times	1^A	1^A	1^A
Substrate Class	A,B,or C	A	**0.3**	**0.3**	**0.3**
% Riffle Fines	<50	<10	**0**	**0**	**0**
Nitrate-Nitrogen	.01 - .04, or .91 -2.0	.15 - .25	1^A	1^A	1^A
% Cover	>10	>20	1	1	1
Substrate Cover	>5	>15	**0**	**0**	**0**
Embryo Component					
Minimum D.O.	>6.5	>13	**0.1**	**0.1**	**0.1**
Max. or Min. Temperature	1.5 - 15 C	4.5 - 13 C	**0**	**0**	**0**
Average Gravel Size	A>0.3, B>1.0	A>5, B>5	**0**	**0**	**0**
Average Water Velocity	25 - 100 cm/s	32 - 85 cm/s	**0**	1	1
% Fines	A<12, B<27	A<5, B<5	**0**	**0**	**0**
Average Base Flow	>20	>50	1^A	1^A	1^A
Average Peak Flow	<5.5 Times	2-3 Times	1^A	1^A	1^A

Table 7-2 (cont'd).

			Old Alamo Creek Suitability Indices		
Steelhead Trout					
Adult Component					
Average Thalweg Depth	>26 cm	>45 cm	0 - 1	1	1
% Instream Cover	>2	>24	1	1	1
% Pools	0 - 100%	35 - 65%	0.5 - 0.8	0.4 - 1.0	**0.3**
Pool Class Rating	A,B,or C	A	**0.3**	0.6	**0.3**
Juvenile Component					
% Instream Cover	>1	>14	1	1	1
% Pools	0 - 100%	35 - 65%	0.5 - 0.8	0.4 - 1.0	**0.3**
Pool Class Rating	A,B,or C	A	**0.3**	0.6	**0.3**
Fry Component					
% Substrate Size Class	>3%	>10%	**0**	**0**	**0**
% Pools	0 - 100%	35 - 65%	0.5 - 0.8	0.4 - 1.0	**0.3**
% Riffle Fines	<45%	<10%	**0**	**0**	**0**
Embryo Component					
Average Max. Temperature	3 - 17 C	7 - 10 C	**0**	**0**	**0**
Average Min. D.O.	>5.5	>9.0	**0**	**0**	**0**
Average Water Velocity	16 - 83 cm/sec	30 - 70 cm/sec	**0**	0.9 - 1[A]	0.4 - 0.6
Average Gravel Size in Spawning Areas	0.5 - 8.5 cm	1.5 - 6 cm	**0**	**0**	**0**
% Riffle Fines	<18%	<4%	**0**	**0**	**0**
Other Component					
Max. Temperature	6 - 18 C	12 - 14 C	**0**	**0**	**0**
Average Min. D.O.	>5.5	>9.0	**0**	**0**	**0**
pH	5.5 - 9.0	6.5 - 8.0	1[A]	1[A]	1[A]
Average Base Flow	>15%	>50%	1[A]	1[A]	1[A]
Predominant Substrate Type	A,B,or C	A	**0.3**	**0.3**	**0.3**
% Streamside Vegetation	>50	>150	0.75 - 1.0	0.6 - 1.0	0.58
% Riffle Fines	<45%	<10%	**0**	**0**	**0**
% Streamside Vegetation (Erosion)	>25%	>75%	1[A]	1[A]	1[A]
% Midday Shade	0 - 100%	50 - 75%	0.8 - 1	0.75 - 0.95	**0**
% Average Daily Flow	>50%	>110%	1[A]	1[A]	1[A]

The juvenile and embryo lifestages, which are related to the outcome of spawning, are limited by many variables including substrate class (SI = 0.3), percentage of riffle fines (SI = 0), substrate cover (SI = 0), average gravel size (SI = 0), percent fines (SI = 0), as well as maximum temperature (SI = 0) and minimum D.O. (SI = 0).

<u>Steelhead trout</u>. The embryo, fry, and juvenile lifestages, are addressed in the HSI analyses for this species. These analyses indicate that spawning potential is limited (SI ≤ 0.3) or unsuitable (SI = 0) for many of the component habitat variables. Temperature, dissolved oxygen, and substrate are minimal or limiting (SI ≤ 0.3) for all three lifestages, and water velocity is limiting in the segment upstream of EWWTP.

7.2.3 Results

Figure 7-2 summarizes the decision framework for determining whether water quality and habitat conditions are sufficient to attaining the SPWN use. Based on the results of the analyses presented above, SPWN does not exist for most relevant migratory species because of a number of factors including water quality (high temperatures and low minimum dissolved oxygen), habitat limitations (substrate size, percentage of pools, and substrate cover), and channel modification (disconnection of Old Alamo Creek with its upper watershed). In addition, the presence of physical barriers to fish migration (see Chapter 6) further constrain Old Alamo Creek as a viable spawning stream for anadromous and catadromous species.

7.3 Step 3: What factors preclude the attainment of the SPWN beneficial use?

Results indicate that spawning may be theoretically attainable for some anadromous fish species (American shad, sturgeon) in Old Alamo Creek. Cold water fish spawning is limited by many of the same factors identified previously under the COLD use: migration barriers, unsuitable substrate, and lack of suitable cover. As explained in Chapter 5, temperature is also a factor limiting cold water species, however, temperature is affected largely by elevation and the fact that the channel has been modified such that Old Alamo Creek is cut off from its upper watershed. For warm water anadromous species, habitat is theoretically suitable downstream of the EWWTP discharge, where there is sufficient flow. Migration barriers, as discussed in Chapter 6, are limiting SPWN use for warm water anadromous species in this stream (see Figure 7-2).

7.4 Step 4: Is restoration feasible?

Restoration options for achieving SPWN attainment for cold water fish in Old Alamo Creek are limited as explained in Chapter 5 (COLD use) and Chapter 6 (MIGR use for cold water fish). Hydrological modifications in the form of flapper gates at the downstream confluence with New Alamo Creek, and disconnection with the upper watershed, limit the ability of all anadromous fish to migrate into Old Alamo Creek.

Removal of Flapper Gates

Even if the flapper gates were removed, physical habitats constraints would prevent attainment of the SPWN use for cold water fish. These constraints would require substantial modifications to the existing channel including: (1) input of larger sediment (gravel, cobble), (2) addition of channel structures to create more riffles and better pool cover, and (3) riparian habitat improvement to further create cover and stream shading. For warm water anadromous species, SPWN might be attainable if migration access was improved via removal of the flapper gates. It is not known whether removing these gates would alter the hydrology causing deleterious effects on land uses or other water uses in Old Alamo Creek.

Reconnect Old Alamo with its Upper Watershed

Old Alamo and the diversion point (New Alamo) have become developed suburban neighborhoods within Vacaville. The “headwaters” of Old Alamo are now within Nelson Park, which is .28 mile from the diversion point. To reconnect Alamo with Old Alamo would require extensive modification of city streets and neighborhoods that now lie between the two points. In addition, a careful analysis of the flood hazard represented by the reconnected channels would have to be undertaken.

Basis for Removal of Designated Use

The CWA factors for allowing a State to remove a designated use are listed in 131.10(g). Several 131.10(g) factors preclude attainability of SPWN use in Old Alamo Creek (see Figure 7-2) as described below.

For removal of SPWN for Old Alamo Creek, it has been demonstrated that attaining the designated use is not feasible because of factor 131.10(g)(4): “*Dams, diversions, or other types of hydrologic modifications preclude the attainment of the use, and it is not feasible to restore the water body to its original condition or to operate such modification in a way that would result in the attainment of the use*.” Due to the fact that Old Alamo Creek has been cut off from its upper watershed, there are no areas to which spawning species could migrate and reasonable carry out spawning activities. Furthermore, hydrologic modifications on both the upstream and downstream ends of this Creek constitute impassable barriers (iron flapper gates downstream and no channel upstream). Thus, the stream has little or no means of recruiting migrating fish (warm or cold) from downstream sources.

In addition, SPWN use is not attainable because factor 131.10(g)(5) is present: “*Physical conditions related to the natural features of the water body, such as the lack of a proper substrate, cover, flow, depth, pools, riffles, and the like, unrelated to water quality, preclude attainment of aquatic life protection uses.*” Several natural features of Old Alamo Creek are not conducive to anadramous fish spawning including substrate size, pool depth, riffle quality, and temperature in the case of cold water anadramous fish. The latter parameter is a consequence of both the low elevation and warm region in which the Creek is located as well as hydrologic modifications as noted above, which prevent cooler water from reaching this Creek.

In this case, SPWN is not a 101(a) use and is a result of State policy applying beneficial uses to tributaries. Old Alamo Creek has not demonstrated SPWN use qualities nor has there been any societal demands to use Old Alamo Creek in this way. Therefore, it is not necessary to evaluate potential widespread economic and social impacts of potential remedies that may be technically feasible (but impractical) because an investment in restoration technology would be inappropriate if the waterbody is not likely to be used by anadramous fish.

Therefore, as a result of a combination of factors described in 40 CFR 131.10(g)(4), and (5) of the Federal water quality standards regulation, the SPWN designation of Old Alamo Creek does not apply for purposes of interpreting the tributary policy of the Regional Board.

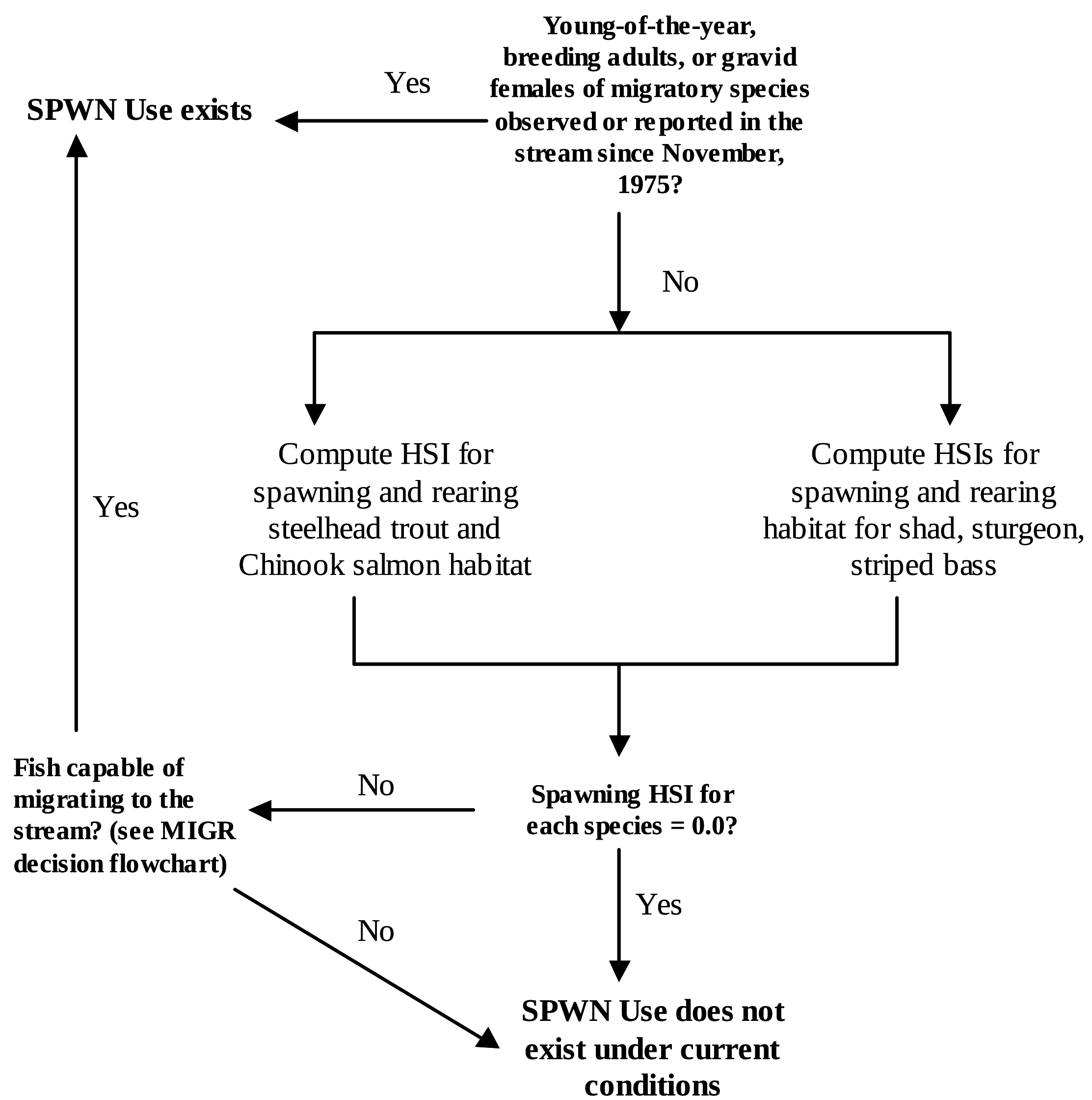


Figure 7-2. Decision tree for determining whether water quality and other factors support the existence of SPWN use.

8. Evaluation of Attainability for Municipal and Domestic Drinking Water Supply

The Basin Plan defines MUN as "[u]ses of water for community, military, or individual water supply systems including, but not limited to, drinking water supply."

The State Water Resources Control Board Resolution 88-63 "Sources of Drinking Water Policy," established a State policy that all surface and ground waters of the State be considered as sources of drinking water. However, the policy also established certain exceptions, and identified conditions and/or waters that are exempted from use as a supply source for drinking water. In the policy exceptions, the resolution indicated that waterways constructed with the primary purpose to receive and convey agricultural drainage waters may be excluded from being a source of drinking water.

When the Regional Board incorporated SWRCB Resolution 88-63 into the Basin Plan, all unlisted waters were designated as municipal and domestic water supply (MUN). Therefore, the indicators used in this UAA address both the State policy (i.e., Resolution 88-63) and the CFR 131.3(g) factors that would impact potential water supply capabilities of Old Alamo Creek.

It should be noted that if the Regional Board amends the Basin Plan to remove Old Alamo Creek's MUN designation, the State Board will consider amending Resolution No. 88-63 concurrently with the action of the Regional Board to specifically exempt that waterbody.

8.1 Step 1: Is the designated use being attained?

8.1.1 Background

Historical records indicating that the waterbody has been used as a source of municipal or domestic drinking water (MUN) since November 28, 1975, would demonstrate that the MUN use is being attained.

8.1.2 Data Collected

A physical survey of the area was conducted to look for evidence of intake pipes. Interviews were conducted with staff from the Regional Board, City of Vacaville, Solano Irrigation district, and several local residents.

8.1.3 Results

Findings by the State Water Resources Control Board (Order WQO 2002-0015 in the Matter of the Review on Own Motion of Waste discharge Requirements Order No. 5-01-044 for Vacaville's Easterly Wastewater Treatment Plant), and record searches indicate that MUN is not an existing or historical use of Old Alamo. Interviews included local officials, Department of Health Services staff, Regional board staff, and local residents. A site survey of the creek did not identify any water intake pipes or near-channel storage tanks also indicating that MUN is not an existing use in Old Alamo Creek.

8.2 Step 2: Is water quality sufficient to attaining the beneficial use?

8.2.1 Background

There are three major factors that may preclude a waterbody from being used as a source of drinking water supply that are considered for MUN use attainability: Adequate flow volumes, acceptable water quality, and the conditions of resolution 88-63 (see Conceptual Model, Figure 8-1).

Flow In order to be used as a source of drinking water, a water source must be able to provide a consistent and adequate flow volume to support municipal or domestic demands. Inadequate or marginal natural background flows would mean that there needs to be an assessment of treating effluent discharge flows as a source of water in Old Alamo Creek.

Water Quality and public health conditions Water used for public consumption must meet drinking water quality standards based on Maximum Contaminant Levels (MCLs). Criteria from the California Toxics Rule for MUN waters must also be met for MUN to be attained.

A Department of Health Services policy memorandum 97-005 (Policy Guidance for Direct Domestic Use of Extremely Impaired Sources) describes conditions defining impaired sources that should be avoided as a supply source for drinking water. The memorandum identifies several examples and includes the following recommendation against the use of drinking water supplies from: “Water that is predominantly recycled water; urban storm drainage; treated or untreated wastewater; or is agricultural return water.” Treated wastewater from a treatment plant or agricultural return water may contain human pathogens including *Cryptosporidium*, *Giardia*, poliovirus and hepatitis virus for which no numeric criteria have been established to protect MUN-designated waters. Additionally, no rapid and reliable quantitation methods exist for these pathogens that are capable of demonstrating short-term compliance with such criteria were they to exist. All agencies charged with protecting public health and water quality have significant concerns about directly using treated effluent or agricultural return water for domestic supplies without dilution because of the threat posed by pathogens without extensive treatment.

Resolution 88-63 Exemption

The State Water Board Resolution No. 88-63, 'Sources of Drinking Water Policy' established exceptions to the policy that include waterbodies where:

- X "There is contamination, either by natural processes or by human activity (unrelated to a specific pollution incident), that cannot reasonably be treated for domestic use using either Best Management Practices or best economically achievable treatment practices, or
- X "The water source does not provide sufficient water to supply a single well capable of producing an average, sustained yield of 200 gallons per day, or

- X The water is in systems designed or modified to collect or treat municipal or industrial wastewaters, process waters, mining wastewaters, or stormwater runoff, provided that the discharge from such systems is monitored to assure compliance with all relevant water quality objectives as required by the Regional Boards or
- X The water is in systems designed or modified for the primary purpose of conveying or holding agricultural drainage waters, provided that the discharge from such systems is monitored to assure compliance with all relevant water quality objectives as required by the Regional Boards.

8.2.2 Data collected

Flow

Flows within Old Alamo were evaluated using monitoring data from stations upstream of the EWWTP provided by the City of Vacaville. The upstream monitoring stations are sampled during the wet months (November through April) because flows are virtually nonexistent during the dry months (May through October). During the monitoring period of January 2002 through April 2003, there were a total of 57 sampling events. Flows are recorded in three categories: flow, low flow, and no flow. The City of Vacaville monitoring team estimated that the volume of a low flow event is at or below 1 cfs. The complete flow database is included as Appendix D. Table 8-1 summarizes the flow database for two monitoring sites upstream of the Kinder Morgan and EWWTP discharges. Observations from these stations reflect the natural background flow conditions of Old Alamo Creek.

To supplement the short-term monitoring database, hydrological modeling was used to simulate flow conditions over a fifteen-year period. The Soil and Water Assessment Tool (SWAT) was used to develop estimates of daily flows in the Old Alamo Creek. The SWAT model is physically based, using information about weather, soil properties, topography, and vegetation to predict watershed hydrology and stream flow (Neitsch et al., 2001). Specifically, the SWAT model uses precipitation, maximum and minimum air temperature, relative humidity, wind speed, and solar radiation to simulate the meteorology of the system. These inputs were statistically generated using historical weather data collected at the Sacramento Airport and adjusted to reflect the higher rainfall amounts seen in the Vacaville area. Soil properties for the watershed including hydrological group, permeability, and composition were extracted from the USDA State Soil Geographic Data Base (STATSGO). Land use was classified into six urban and rural classes based on USGS land use data. Model input files were developed to represent ten distinct soil/land use combinations. The model does not attempt to evaluate stream-bed infiltration of low flows. Therefore any flows estimated by the model at or below 1 cfs were assumed to be a no flow condition. The results of the modeling analysis are provided in Table 8-2 below.

Modeling analysis estimates a higher frequency of potential flow conditions than the monitoring observations indicate. However, the modeling simulation indicated that the Old Alamo channel, upstream of the EWWTP discharge, can be expected to be dry approximately two-thirds of the year; there would be minimal or no flow during the high demand summer months in the upstream portion of Old Alamo Creek. This analysis suggests that Old Alamo natural background flows (not influenced by wastewater effluent or agricultural return water) would not be able to support a minimal water supply function.

Water Quality

The majority of flow in Old Alamo Creek is generated from agricultural return flows and the discharge from the City of Vacaville EWWTP treated effluent as demonstrated in Chapter 2 of this document. Effluent data provided in SWRCB/OCC File A-1375 (2002) were reviewed and compared to MUN water quality standards. In addition, available in-stream chemical monitoring data, provided by the City of Vacaville, were also evaluated and compared with MUN water quality standards if available.

Nitrate: Infants below the age of six months who drink water containing nitrate in excess of the MCL could become seriously ill and, if untreated, may die. Symptoms include shortness of breath and blue-baby syndrome. Table 8-3 summarizes effluent nitrate data collected between 1996 and 1997. The range of nitrate concentrations reported during this time period was 8 to 21.3 mg/L, with an average of13.6 mg/L. The MCL for nitrate is 10 mg/L, therefore, effluent data indicate consistent violation of the MCL for nitrate without additional treatment. However, the EWWTP effluent is not the only source of nitrate in Old Alamo Creek. Figure 8-2 summarizes nitrate data collected at the effluent, 1 mile downstream (at the SID agricultural return water discharge), and 3.2 miles downstream of EWWTP, prior to the confluence with New Alamo Creek, between 2002 and 2003. These data demonstrate that significant concentrations of nitrate are contributed by the surrounding agricultural uses.

Dissolved Solids: High total dissolved solids (TDS) have also been measured in the EWWTP treated effluent (Table 8-3). The secondary standard for TDS in drinking water is 500 mg/L; concentrations higher than this value may result in taste and aesthetic problems, laundry staining. The EWWTP effluent routinely had TDS concentrations greater than 500 mg/L.

Fecal Coliform: Total coliform bacteria were often greater than 3,000 MPN (bacterial colonies)/100ml at various points downstream of the EWWTP discharge in the Creek. The MCLG (the level of a contaminant in drinking water below which there is no known or expected risk to health) is zero and the MCL (the highest level of a contaminant that is allowed in drinking water) is less than 5.0% of the samples are total coliform-positive in a month. Generally, a concentration < 200 MPN/100 ml is required in treated wastewater effluent for the protection of human health and disinfection treatment at

Vacaville is adjusted to achieve minimal bacterial concentrations in the effluent. The presence of fecal coliform and related bacteria indicate that the Creek may be contaminated with human or animal wastes from sources other than EWWTP. Likely sources include the SID return water from agricultural irrigation, wildlife (birds and mammals inhabiting the area near the Creek), and the Fry Ranch, which is an intensive beef cattle operation. Disease-causing microbes (pathogens) in these wastes can cause diarrhea, cramps, nausea, headaches, or other symptoms. These pathogens may pose a special health risk for infants, young children, and people with severely compromised immune systems.

Other Pathogens: No data exist for other pathogens such as viruses and protozoans in Old Alamo Creek. Treated wastewater effluent or agricultural return water may contain other human pathogens including the protozoans *Cryptosporidium* and *Giardia*, both of which have MCLGs of zero. Other pathogens such as viruses (e.g., poliovirus and hepatitis virus), and a variety of nematode and trematode parasites may also occur, for which no numeric criteria have been established to protect MUN-designated waters. Given the high percentage of agricultural land uses surrounding Old Alamo Creek (see Chapter 2) and the WWTP effluent, it is highly likely that these other pathogens could occur in Old Alamo Creek, increasing the risk to human populations who might depend on this water as a domestic or public water supply.

Trihalomethanes: Triholomethanes are formed as a byproduct of disinfection using chlorine. They are known to cause liver, kidney or central nervous system problems and increased risk of cancer. The MCLG for bromodichloromethane and bromoform is zero; the MCLG for dibromochloromethane is 0.06 mg/L. Chloroform is regulated with this group but has no MCLG. The MCL for total trihalomethanes (TTHMs) is 0.10 mg/L. Recent data collected in Old Alamo Creek indicate TTHMs are not in excess of its MCL but that many individual THMs do exceed their MCLs (Figure 8-3). These compounds degrade relatively slowly in water, and therefore concentrations 3.2 miles downstream of EWWTP are still higher than the MCLs for many THMs (Figure 8-3). Thus, trihalomethanes in Old Alamo Creek may represent a risk to human health if used as a water supply.

Pesticides: No data exist for pesticides in Old Alamo Creek.. However, given the high percentage of agricultural land uses surrounding Old Alamo Creek (see Chapter 2) and the wide variety and substantial amounts of pesticides used in the District, it is likely that certain pesticides occur in Old Alamo Creek and some may exceed MCLs in this stream. A total of 1,311,203 pounds of pesticides were applied in the SID in 14,121 applications. While many of the high use pesticides in SID are unlikely to be associated with deleterious human health effects (e.g., sulfur, petroleum and mineral oils), certain toxic pesticides are used in fairly high quantities in SID including chlorpyrifos, diuron, 2-4 D, paraquat, and carbamate. These pesticides are used in a number of applications relevant to the Old Alamo Creek catchment including tomatoes, alfalfa, right of ways, and structural pest control. These applications used 378,785, 80,925, 100,595, and 28,459 pounds of pesticides, respectively, much of which was comprised of toxic chemicals such as those listed above. MCLs for these pesticides are unavailable, except for 2-4 D (0.07 mg/L). Those pesticides that do have MCLs are generally near zero. Many of the pesticides listed above cause nervous system diseases leading to respiratory and circulatory problems. Chlorpyrifos, paraquat, and carbamate all are cholinesterase inhibitors that cause labored breathing, coma, and perhaps death if exposed for prolonged periods. Under shorter exposure periods, all of the above pesticides cause nausea, diarrhea, and skin irritations.

8.2.3 Results

Flow

Results in Table 8-1 indicate that even during the wettest portion of the year, the Old Alamo channel upstream of the EWWTP discharge contains no flow approximately two-thirds of the time. In addition, during many flow events, the volume of water in this part of the channel is below a minimum to provide adequate supply. Thus, independent of the EWWTP discharge, there is little consistent stream flow with which to serve as a municipal or domestic water supply.

Alamo Creek's drainage area is approximately 8,930 acres. The upper Alamo watershed after the diversion is 7,741 acres. Old Alamo drainage area is 586 acres while New Alamo drainage area (not including inputs from upper Alamo) is 600 acres. Thus, the Old Alamo drainage area represents approximately 7% of the original watershed area. This reduction in watershed area represents a significant hydrologic modification to the system.

Water Quality

Data indicate that Old Alamo Creek is not currently meeting drinking water quality standards for a number of parameters. Additionally, the unpredictable health risks from drinking agricultural return water led to policies by the Department of Health Services that discourage the use of effluent dominated waterbodies from being a designated source of drinking water. While Department of Health Services policy is not entirely determinative of whether MUN is attainable, it serves as an indication that other available sources would better serve the area's water supply needs. Clearly, extensive treatment and alternative agricultural practices would be necessary to meet drinking water quality standards in support of the MUN use.

Resolution 88-63 Exemption

No site-specific exemption to MUN was granted by the SWRCB prior to these analyses because none of the 88-63 conditions apply to Old Alamo Creek. However, the SWRCB agreed to consider a site-specific amendment that adds Old Alamo Creek to the list of exceptions, pending results of this UAA.

8.3 Step 3: What factors preclude the attainment of the beneficial use?

The hydrological diversion of flow into New Alamo Creek and out of Old Alamo Creek in the 1960s has significantly impacted the level and frequency of background, natural flows within Old Alamo Creek. For at least 66% of the year, the upper part of Old Alamo Creek is dry. The remaining background flows only occasionally reach levels that would be considered adequate to support a small water supply system. Any system that relies on natural Old Alamo Creek flows would require substantial storage capacity, especially during the high demand summer months. Therefore, the natural background flows of Old Alamo Creek are highly unlikely to provide a source for drinking water supply. The remaining option for water supply is further treatment of the effluent that is discharged into Old Alamo Creek by the EWWTP to meet MUN use standards in Old Alamo Creek.

8.4 Step 4: Is restoration feasible?

Two separate possible forms of restoration are considered based on the current potential suboptimal quality of water from the EWWTP effluent and the current lack of natural upstream water to the Creek.

Treatment of the Wastewater Discharge

Many treatment technologies are available that would allow the City to attain most chemical pollutant objectives and criteria intended to protect MUN in Old Alamo Creek. However, nearly all approved domestic and public water supplies depend on a raw source water that is relatively free of human influences (contaminants, pathogens, etc), or in which human influences are substantially diluted so that water treatment is likely to be effective in minimizing risks to water users. Treated effluent uses a raw water source that is likely to be highly contaminated. Even tertiary treatment and alternative forms of disinfection (e.g., ozone, ultraviolet radiation) cannot guarantee the lack of undesirable byproducts or pathogens that are activated after the water is discharged. As discussed previously, certain contaminants, such as trihalomethanes and viral and protozoan pathogens, are likely to be present in this effluent, even with tertiary treatment, due to the source of the wastewater. As most of these non-bacterial pathogens do not have criteria, and are not easily quantified in a continuous, rapid manner, these contaminants could still pose a risk to populations that consistently rely on such water sources.

Furthermore, as demonstrated in the previous section, the EWWTP effluent is not the only source of human contaminants in Old Alamo Creek. Further treatment of EWWTP wastewater would need to be accompanied by either extensive treatment of irrigation return water and runoff from the SID, and/or major changes in surrounding land use practices in order to reduce risks from pesticides, pathogens, and nitrates below acceptable levels. As shown in Chapter 2, a substantial portion of the dry weather flow in Old Alamo Creek is from the SID. Thus, EWWTP effluent, no matter how highly treated, would be mixed with lower quality water downstream, reducing the benefits to

MUN gained from greater wastewater treatment. Both nonpoint and point source contributions would need to be addressed to attain MUN use in this Creek.

Given the importance of non-point sources of pollutants in Old Alamo Creek, meeting MUN criteria and objectives as effluent limitations in this situation may have little relevance in terms of attaining MUN. Attainment may be assessed either by pollutant concentrations present in a waterbody or by identifying an entity that has or will employ the water for the beneficial use. Even if known chemical and pollutant concentrations met all relevant criteria and objectives, it is unlikely that any person or population would directly employ Old Alamo Creek as a source of drinking water for the reasons discussed above.

Previous attempts to augment drinking water supplies with highly treated effluent have faced opposition throughout the state, often being branded as “Toilet-to-Tap”. (Beverly Hills Citizen; San Diego Union-Tribune, 10/18/92; Water Reuse Association; NIEHS, 2000; North County Times, 05/02/00; Department of Water Resources, 1999.) Projects to reuse effluent in drinking water supplies involve indirect potable reuse where highly treated effluent is mixed with groundwater or added to reservoirs. No project in the state has used undiluted effluent solely as a potable supply.

Currently, the City of Vacaville is able to obtain approximately 32,000 acre-feet of water per year from groundwater and the Sacramento-San Joaquin Delta (http://www.scwa2.com/briefing.html #APPENDIX B/VACAVILLE). This supply, combined with a recent settlement with the Department of Water Resources, is believed to be sufficient for the next 20 years of Vacaville’s needs (Vacaville Reporter; February 23, 2003). Given the availability of both groundwater and surface water to meet Vacaville’s supply requirements, treated effluent is unlikely to be utilized as a source of drinking water for the City for the foreseeable future. If supply augmentation were desired, effluent treated to meet DHS effluent recycling requirements could be traded with local irrigators or used to replace potable supplies that are currently put to non-potable uses. Public support for direct potable reuse of undiluted effluent, or effluent diluted with agricultural return water, is even less likely, particularly in an area with supplies that are believed to be sufficient for another 20 years.

All agencies charged with protecting public health and water quality have significant concerns about using undiluted wastewater for domestic supplies because of the significant threat posed by pathogens. Extensive treatment would be necessary and even then public resistance would be significant if not overwhelming. In addition, this solution would not address unknown contaminants and pathogens entering Old Alamo Creek from surrounding agricultural land uses.

Reconnect Old Alamo with its Upper Watershed

Old Alamo and the diversion point (New Alamo) have become developed suburban neighborhoods within Vacaville (see Figure 8-4). The “headwaters” of Old Alamo are now within Nelson Park, which is .28 mile from the diversion point. To reconnect Alamo with Old Alamo would require extensive modification of several city streets and neighborhoods that now lie between the two points. A minimum of 12 houses currently lie directly within the diversion area. Very likely, a minimum of another 10 homes would be affected by potential flooding if Old Alamo Creek was reconnected with its upper watershed. Pending a thorough analysis of the flood hazard represented by the reconnected channels, it is possible that many more homes and businesses would be affected by flooding in this case (which was the reason that the diversion was constructed in the first place). Furthermore, another consideration with this alternative is that New Alamo Creek would dry up. This water currently serves as an irrigation source to some agricultural businesses who are located too far from Old Alamo Creek to economically use the latter as a water source. In addition, aquatic life would no longer be able to use New Alamo Creek.

Given the other sources available in this area, Old Alamo Creek is not a likely source of drinking water. These supplies are believed to be sufficient for Vacaville's needs for at least the next 20 years. Given the availability of these other sources to meet Vacaville's supply requirements, treated effluent is unlikely to be utilized as a source of drinking water for the City for the foreseeable future. If supply augmentation were desired, effluent treated to meet DHS' effluent recycling requirements could be traded with local irrigators or used to replace potable supplies that are currently put to non-potable uses.

Basis for Removal of Designated Use

The CWA factors for allowing a State to remove a designated use are listed in 131.10(g). Several 131.10(g) factors preclude attainability of MUN use in Old Alamo Creek (see Figure 8-5) as described below.

For removal of MUN for Old Alamo Creek, it has been demonstrated that attaining the designated use is not feasible because factor 131.10 g (2) applies: *Natural, ephemeral, intermittent or low flow conditions or water levels prevent the attainment of the use, unless these conditions may be compensated for by the discharge of sufficient volume of effluent discharge without violating State water conservation requirements to enable uses to be met.*

As demonstrated in this chapter, the upper part of Old Alamo Creek (relatively uninfluenced by human activities) does not provide an adequate supply of water for MUN use. Compensation with treated wastewater is not possible because the discharge point is several miles downstream from the upstream section. Furthermore, California Department of Health Services cautions against using treated effluent and agricultural return flows directly as a source of drinking water. Even in the sections of Old Alamo Creek that do have sufficient flows as a result of wastewater discharges and agricultural drainage, MUN is not currently attained and is unlikely to be attained in any meaningful way in the future. Pathogens, possible treatment plant upsets or storm events that lead to excessive pesticide loading all create a situation where employing Old Alamo Creek as a drinking water supply is ill advised and discouraged.

In this case, the MUN designation is not a Clean Water Act section 101(a) use and is a result of State policy applying beneficial uses to tributaries and the Central Valley Regional Board's implementation of Resolution 88-63 in its Basin Plan. Old Alamo Creek is not planned to be used as a source of drinking water, nor is it likely to be used as a source of drinking water in the future. Therefore, it is not necessary to evaluate potential widespread economic and social impacts of potential remedies that may be technically feasible (but impractical) because an investment in treatment technology would be inappropriate if the waterbody is not intended to be used as a source of drinking water without further [natural] dilution.

Factor 131.10 (g)(4) also applies. The reason Old Alamo Creek lacks sufficient flows to serve as a source of drinking water is the hydrologic modifications that diverted Alamo Creek's flows into the New Alamo Creek channel. Old Alamo Creek became ephemeral upstream of the treatment plant and parts of the former channel were filled. Those filled areas now have houses, roads, parks and businesses on them. Disrupting these residents in order to attain an MUN use in Old Alamo Creek is infeasible and not necessary considering the fact that Vacaville has secured municipal supplies sufficient for the next 20 years.

Therefore, as a result of a combination of factors described in 40 CFR 131.10(g)(2) and (4) of the Federal water quality standards regulation, the MUN designation of Old Alamo Creek does not apply for purposes of interpreting the tributary policy of the Regional Board.

Table 8-1. Old Alamo flow observations above Easterly Waste Water Treatment Plant discharge points. Observation period: November – April, 2002 and 2003.

Station	Observations	No Flow	Low Flow	Flow	% no flow
R1	55	38	6	11	69%
A1	31	18	4	9	58%
All (continuous)	55	38		18	69%

Table 8-2. Results of SWAT modeling analysis showing percent of time that flow in the upper part of Old Alamo Creek is below a given threshold.

Flow	10 cfs	5 cfs	2 cfs	1 cfs	0.5 cfs	0.1 cfs	0.01 cfs
% Time Below	91.9%	81.0%	66.9%	60.9%	53.2%	37.6%	24.0%
# of Days Below	335	296	244	222	194	137	88

Table 8-3. Concentrations of nitrate nitrogen (nitrate-N) and total dissolved solids (TDS) in the Easterly Wastewater Treatment Plant's effluent from 1996-1997. For MUN use, the nitrate-N objective is 10 mg/L and the TDS objective is 500 mg/L.

DATE	NITRATE-N (mg/L)	TOTAL DISSOLVED SOLIDS (mg/L)
Jan 96	13.5	NA
Feb 96	8	552
Mar 96	10.7	582
Apr 96	NA	NA
May 96	11.7	621
Jun 96	10.1	566
Jul 96	14.0	562
Aug 96	21.3	549
Sep 96	9.9	NA
Oct 96	10.2	473
Nov 96	15.2	530
Dec 96	11.2	488
Jan 97	11.5	553
Feb 97	12.6	555
Mar 97	12.3	517
Apr 97	15.1	527
May 97	14.0	586
Jun 97	15.0	590
Jul 97	16.9	516
Aug 97	12.9	552
Sep 97	10.9	511
Oct 97	19.4	570
Nov 97	17.8	554
Dec 97	17.5	533
average	13.6	547

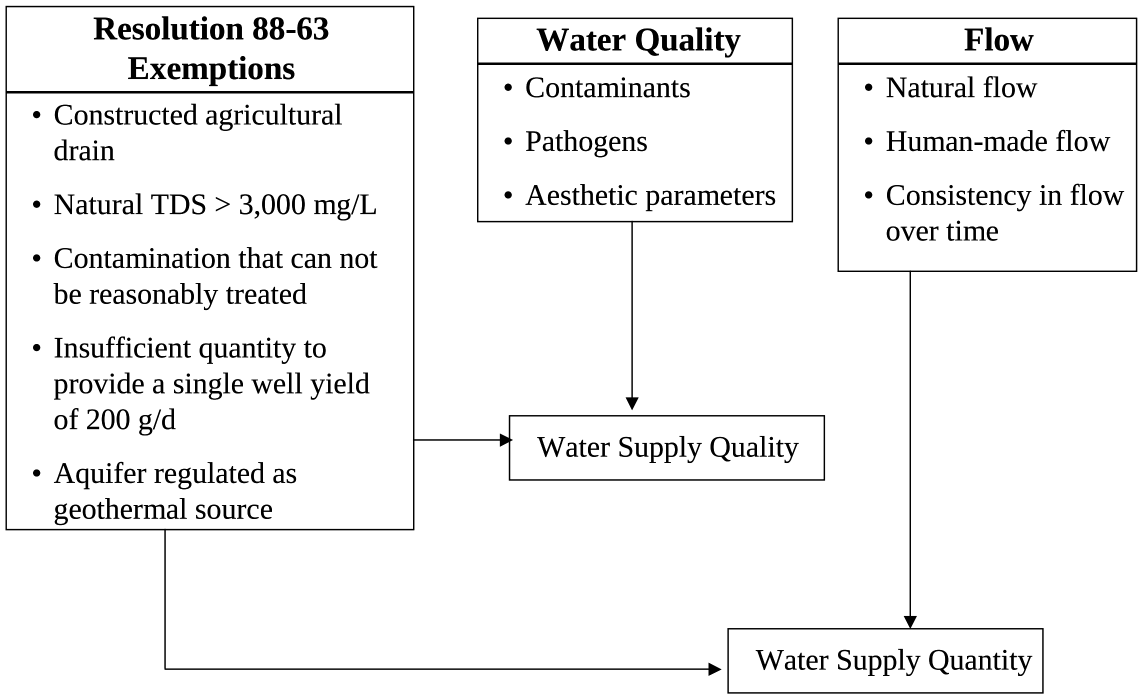


Figure 8-1. Conceptual model showing the major factors considered in evaluating MUN use attainability.

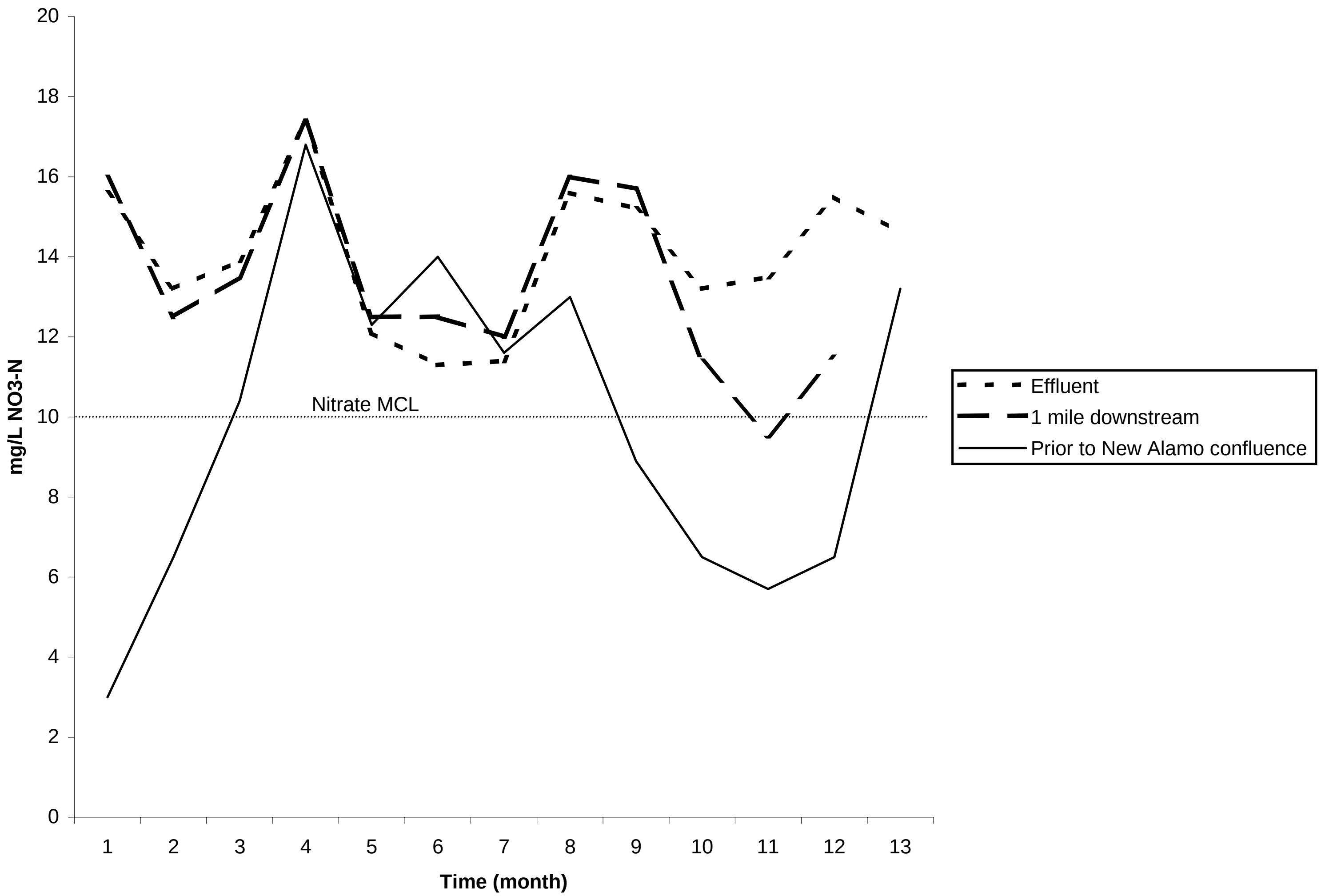


Figure 8-2. Nitrate concentrations between September 2002 and September 9, 2003 in the Vacaville wastewater treatment plant effluent, 1 mile downstream, and prior to the New Alamo confluence in Old Alamo Creek.

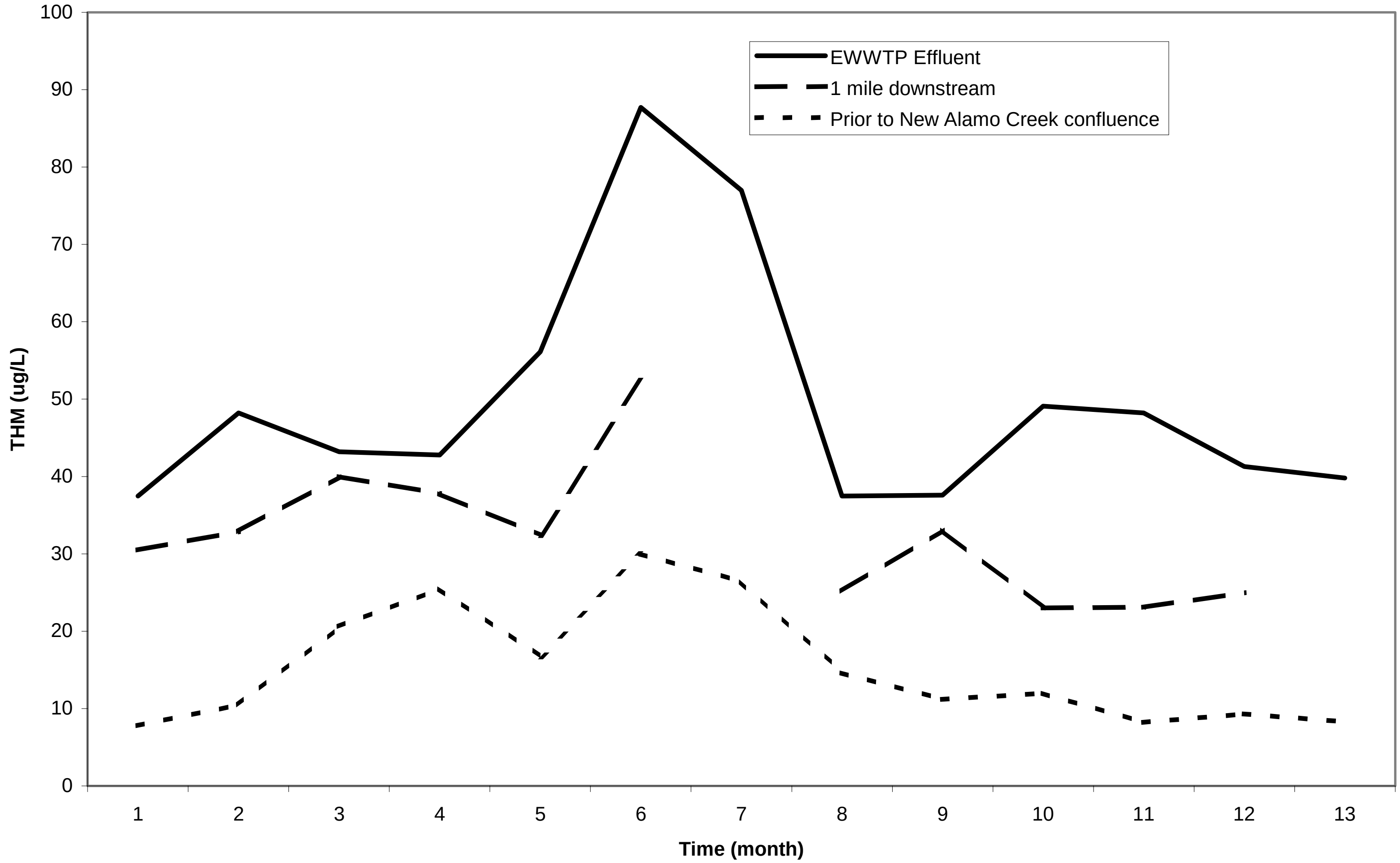


Figure 8-3. Total Trihalomethane (THM) concentrations recorded in Vacaville EWWTP effluent and in Old Alamo Creek, 1 mile downstream and prior to the confluence with New Alamo Creek between September 10, 2002 and September 2, 2003. MCL for total THMs is 100 ug/L. MCLGs for individual THMs measured in these samples is < 60 ug/L.

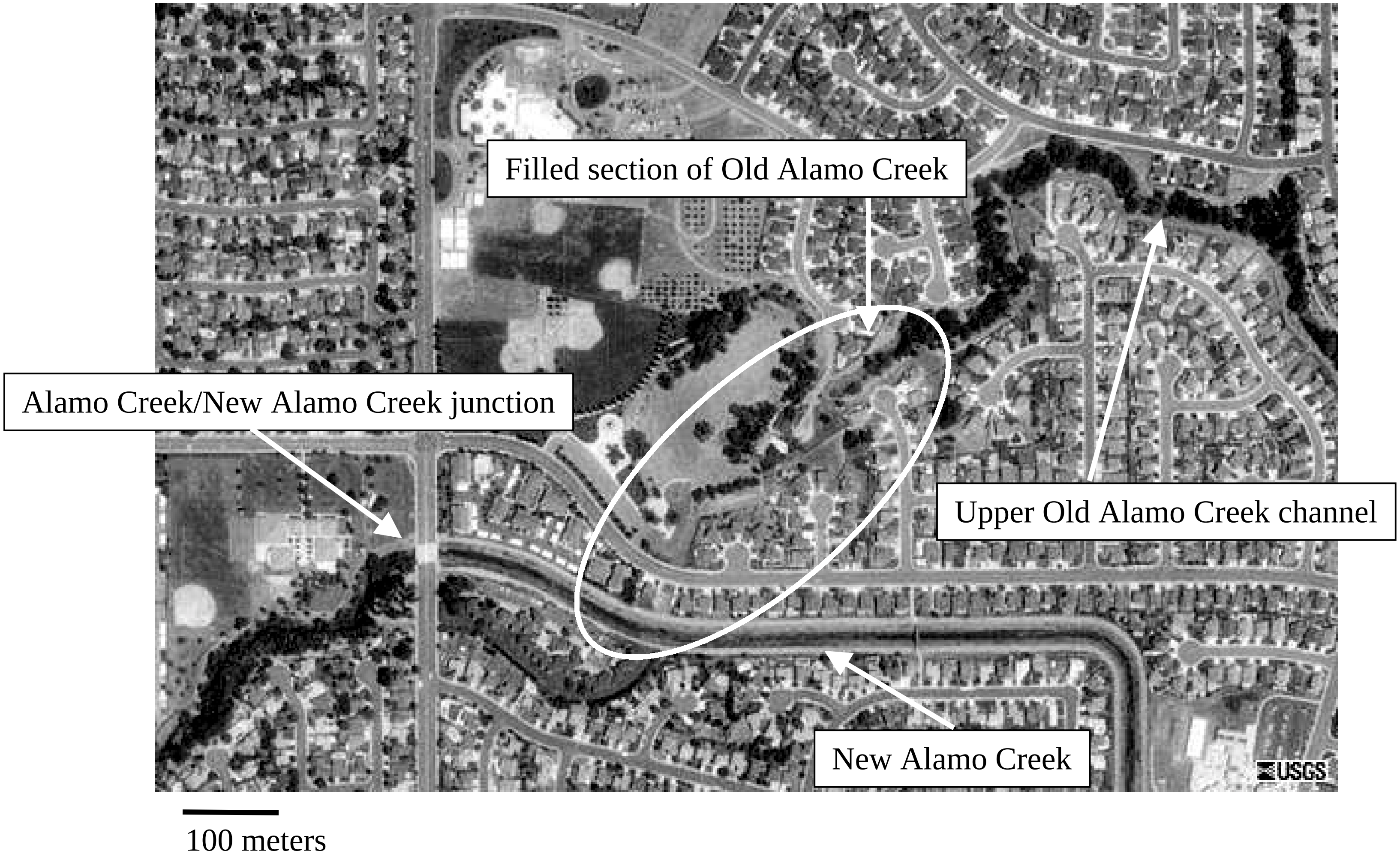


Figure 8-4. Aerial photograph showing the portion of Old Alamo Creek that is disconnected from the upper watershed (Alamo Creek/New Alamo Creek) as it currently exists with housing developments.

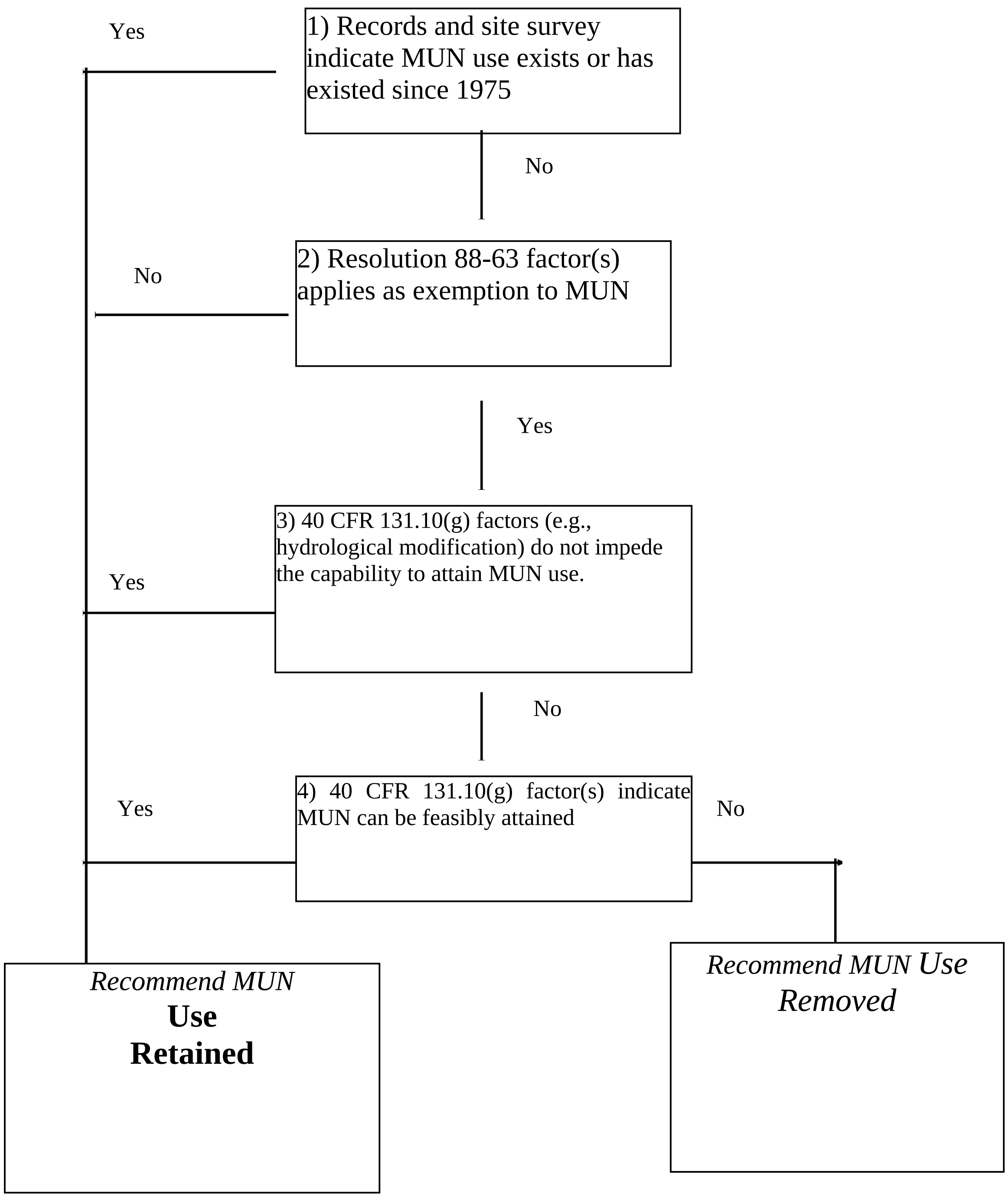


Figure 8-5. Flowchart depicting decision tree for evaluating MUN use status.

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